Final Report

Westinghouse
Health Systems

Systems Analysis Study Towards a New Generation of Military Hospitals

Volume 1
Executive Summary

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SYSTEMS ANALYSIS STUDY TOWARDS
A "NEW GENERATION" OF MILITARY HOSPITALS
VOLUME I: EXECUTIVE SUMMARY

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ABSTRACT

This is Volume I, Executive Summary, of Westinghouse Electric Corporation's five volume final report on the Systems Analysis Study Towards a "New Generation" of Military Hospitals, submitted in accordance with Contract No. DAHC15-69-C-0354, sponsored by the Advanced Research Projects Agency under ARPA Order No. 1494, and Program Code 9K10. The scope of the study described in RFQ No. DAHC15-69-Q-0045, was amended by letter dated March 8, 1969, from the Assistant Deputy Director for Procurement, Department of the Army, Defense Supply Service, Washington, D.C.

Other volumes in the report are:

Volume II, Systems Analysis

Volume III, Medical Health Care Review

Volume IV, State-of-the-Art

Volume V, Data Inventory

This study is Phase I of a program in which the primary objective is to improve the operating efficiency of individual Base Level Health Care (BLHC) Systems, including inpatient and outpatient responsibilities, while maintaining or improving the quality of patient care. A further objective is to reduce costs of BLHC operations and place health care planning decisions on the basis of life cycle cost rather than first costs. A secondary Phase I objective is to identify longer range R&D goals for improved 1975-1980 BLHC Systems.

This study is part of an on-going 10 year program within the Office of the Assistant Secretary of Defense (Health and Environment). Phase I - Systems Analysis (just completed); Phase II - Design and Construction (by 1972); and Phase III - Evaluation and Implementation of Long Term R&D Programs (1975-1980).

The RFQ, as amended, focused the study on fixed base level systems in the Continental United States (CONUS) with these parameters:

Beneficiary Population	Beds	Outpatient Visits Per Year
40,000 - 50,000	250	300,000
60,000 - 80,000	500	450,000
80,000 -100,000	750	650,000

The contract specified three BLHC Systems to be studied in depth by size, military service, and location, and six other BLHC Systems designated for general examination and evaluation. The DoD also made available numerous other data of a service-wide nature.

A multidisciplinary approach was taken; Westinghouse formed a consortium of companies and individual professionals from research, engineering, architectural, industry, management sciences, and health fields to study and perform a systems analysis on the BLHC System. The analysis is now complete and the contract has been successfully fulfilled. The Westinghouse Team has made an effective bridge of the semantics and communications gap between the medical health care professions and those of engineering and industry.

The study output generated in response to the RFQ category, "Operations Analysis," appears in Volume III, Medical Hoalth Care Review, and Volume V, Data Inventory. These report the analysis of the present BLHC System and contain:

- specific, detailed descriptions of BLHC performance characteristics;
- documented functional costs;
- characterizations of flows of people, materiel, and communications; and
- observations of health care practices and recommendations for improvements.

In addition to these data, approximately 33,000 pages of computer data generated during data analysis have been microfilmed and sent to the DoD, as a data resource for continuing analysis.

These bodies of data provided a comprehensive understanding of the BLHC System as it exists. The data revealed that, generally, the military system is excellent. The BLHC System is one of the most comprehensive health care systems in the world; the staff is of high caliber and utilization of allied health care manpower is among the best in the country. The data also revealed areas where distinct opportunities for improvement lie. Unmet needs became apparent, and the limitations inherent in planning based on historical workload came into focus.

Needs for improvement in three functional areas of the System became evident -- in planning, facilities design, and operations.

- In planning, a need for a better method of predicting the changing health care demands and the resource requirements of a BLHC System over its life cycle.
- In facilities design, a need for a System design which can respond more adequately and economically to health care needs not only initially, but after significant changes and substantial growth.
- In operations, a need for improved resource management and the evaluation of sub-system or functional improvement opportunities which are already operational or which are likely to be in the near future.

The study outputs generated in response to the RFQ category "Improvement Analysis" are contained in Volume II, Systems Analysis, and Volume IV, State-of-the-Art. All available relevant technology, operational, or procedural improvements which could contribute to the objectives of the overall study were identified and reviewed in Volume IV. A comprehensive systems analysis on these items is contained in Volume II.

The total study has produced tools for planning, design, and operations, tools immediately usable for the BLHC System as well as applicable to the non-military sector including HEW and Veterans Administration hospitals. Specifically, the Westinghouse Consortium has assembled, adapted, or created:

(1) Data Resource -- a massive fund of data on health care systems in general and on BLHC Systems in particular;

(2) Demand Model -- a tool to predict specific demands upon BLHC Systems over time and thus the resources required to meet them;

(3) Design Concept -- a logic which, when realized in a facility, will organize health care resources for most effective overall health care delivery while providing flexibility for change and growth at least-cost over the life cycle;

(4) Operational or Sub-systems Analyses -- cost/benefit analyses of operational alternatives in ten major functional elements selected for their high potential for cost savings or because their roles are critical to the overall system.

- Communications and Data Management
- Materiel Handling
- Dietary
- Clinical Laboratories
- Dental
- Outpatient Clinics
- Ward Management
- Education and Training

- Pharmacy
- Radiology

Westinghouse has tested these several tools, concepts, and techniques in a specific example of a hypothetical BLHC System, Base "X". A base mission population of 75,000 was chosen which falls in the mid-range of the BLHC Systems defined in the RFQ. The mission was varied by increases in the major beneficiary populations and by a gradual growth in the retired component.

The population, with age/sex characteristics similar to those of a CONUS military base was processed by the Demand Model to produce a quantitative description of the range of health care resources needed. Those requirements were used to generate specific facility configurations using the new design logic and current criteria. This process demonstrated that both the design logic and the various operational improvement recommendations were capable of meeting the range of demands.

The Base "X" test was a success. The Demand Model was shown to be an effective tool for providing specifications for the BLHC System. The Design Logic was proven capable of incorporating operational improvements and accommodating change and growth while preserving essential organization logic at lower life cycle costs. For the test situation a Westinghouse computer program called Dynamic Planning, was used to pace facilities expansion. When combined with the results of the operational cost/benefits, the test showed that using the Westinghouse improved criteria and recommended sub-system alternatives, the expected life cycle cost of Base "X" was 10 to 15 percent lower, measured against current DoD criteria and operating functional costs. In yearly operating costs, calculated for the first full year of operations, the recommended operational alternatives save approximately 12 percent for inpatient services and 5 percent for outpatient services.

For DoD, the yields of the Westinghouse study:

- provide pragmatic solutions to fundamental BLHCS problems in planning, design, and operations -- solutions applicable (1) in a full-scale Phase II test facility, and (2) to retrofit situations in many areas.
- will produce dollar savings.
- shorten the planning and design process and lead to earlier occupancy.
- provide a framework for continuing planning and design.
- establish baseline data for measuring future improvements.

Westinghouse recommends that DoD:

- proceed with Phase II using Phase I results as a framework for the 1972 prototype BLHC System.
- regard Phase II as a single R&D project to test, evaluate, and refine the tools and concepts developed in Phase I.
- use for Phase II the same interdisciplinary approach as Phase I, with a cadre of DoD planners matching the project structure of the industrial consortium.
- proceed with short term R&D recommendations in support of 1972 design and long term R&D for 1975-1980 application.

Westinghouse also recommends the following changes in guidelines and criteria:

- Use a predictive approach to planning based on population to replace the historical workload approach.
- Use a systems approach to the sequence of planning, design, and construction.
- Institute life-cycle costing for BLHC Systems.
- Institute life-cycle costing for operational improvements.

TABLE OF CONTENTS

1. INTRODUCTION

The Westinghouse Systems Analysis Study Towards a "New Generation" of Military Hospitals (NGMH) has been performed to identify and describe potential improvements in facilities, resources, and programs of the Base Level Health Care (BLHC) Systems operated by the Department of Defense for 10 million eligible military on active duty or retired, their dependents, and dependents of deceased military personnel.

This study is Phase I of an ongoing development effort. The objectives of the Westinghouse Phase I effort were:

- to mobilize health care resources for maximum effectiveness and efficiency
- to minimize system life cycle costs, including operating and capital expenditures
- to enable the System to respond to changes in technology, health care trends, and mission or policy.

Phase II will implement Phase I concepts and develop other promising system improvements. Continuing effort through Phase II and beyond will lead to a New Generation of Military Hospitals.

SCOPE OF THE STUDY

The scope of Phase I of the NGMH study was the performance of systems analyses toward improving the construction, planning, maintenance, and training efficiency of the individual BLHC System while maintaining or improving the quality of patient care. A BLHC System is defined as the facilities and resources necessary to provide a full range of health care services to the components of the military community, armed forces personnel, their dependents, and other authorized categories residing on, adjacent to, or referred to the system. It will also provide designated health care services and military command and control responsibilities to health care facilities beyond its established boundary. (These are considered external demands upon the BLHC System.)

The basic mission of the BLHC System is to:

- Maintain the physical, mental, and operational fitness of the assigned population
- Prevent and control the incidence of disease and injuries within the BLHC System

The services provided by a Base Level Health Care System include:

- General short-term hospital beds with related diagnostic and therapeutic capability
- Inpatient and outpatient clinics
- General and preventive dentistry
- Dispensary care
- Aerospace and aviation medicine
- Preventive medicine
- Mental and social health care
- Veterinary medicine

The external demands that are placed upon the BLHC System can be defined as:

- The treatment of battle casualties
- The designation as a medical and dental specialty treatment center
- Area medical materiel management responsibility
- Area medical command and control responsibility
- Intransit aeromedical evacuation facilities.

Phase I was divided into three basic activities:

- Operations analysis
- Improvement analysis
- Results and recommendations

The operations analysis described the performance of individual BLHCS, elements, functions, and sub-systems. It investigated and documented major functional costs, and it characterized the basic flows between functions.

The DoD selected three specific BLHC Systems for Westinghouse to study in depth and six BLHC Systems for general examination. The Systems were a representative sample of base missions and health care services.

The hospitals selected for in-depth study were:

280-Beds	Beaufort Naval Hospital, Beaufort, South Carolina
350-Beds	Malcolm Grow USAF Hospital, Andrews AFB, Maryland
900-Beds	Walson Army Hospital, Fort Dix, New Jersey

The hospitals selected for general examination and evaluation were:

175-Beds	USAF Hospital, March Air Force Base, California
250-Beds	U.S. Army Hospital, Fort Belvoir, Virginia
400-Beds	U.S. Naval Hospital, Jacksonville, Florida
500-Beds	U.S. Army Hospital, Fort Bragg, North Carolina
750-Beds	U.S. Air Force Hospital, Lackland AFB, Texas
650-Beds	U.S. Naval Hospital, Oakland, California

The improvements analysis assessed major improvement alternatives in terms of technology and its state of development, its impact on hospital management and organization, and its impact on BLHC organization and functions. Other considerations were: additional research and development required, the levels of uncertainty associated with possible alternatives, and policy issues raised by them. The improvement alternatives were submitted to a systems analysis and appropriately tested and evaluated. Cost/benefit studies on major improvement alternatives helped develop specifications and requirements for all recommended improvements.

Recommendations are made, in this Executive Summary and in appropriate volumes, first for construction of a prototype starting in mid-1972 and second, for long-term research and development in the 1975-1980 time frame.

THE WESTINGHOUSE APPROACH

Using a multidisciplinary approach, Westinghouse formed a Consortium of companies and individual professionals from the research, engineering, architecture, industry, management sciences, medicine, nursing, hospital administration, and health law fields. In a sense, only a multidisciplinary systems approach could be successful, since from the outset it was apparent that military hospitals are elaborate and complex systems which blend the "hard" sciences of engineering and construction with the "soft" sciences of medicine and health care.

The objective of the systems approach was to provide a total conceptual framework to accommodate both quantitative analysis and subjective evaluation. Many areas of the systems analysis required the highest level of judgment and experience from the professional specialists in the Consortium. The study's success can be directly traced to workable evaluations of the many qualitative factors that are integral to any health care system. Wherever possible, Westinghouse has identified in this report the areas where qualitative factors are important and how these factors relate to the analysis.

Six major tasks were defined in the Westinghouse proposal.

1. Pre-project Planning -- Westinghouse-funded effort to acquaint the Consortium with the military BLHC System and initiation of the state-of-the-art survey (SOA).
2. Preliminary Data Inventory -- the analysis of the data pack supplied by DoD.
3. Data Inventory -- detailed data collection and observation in nine military BLHC Systems.
4. Systems Analysis -- identification of alternative improvement possibilities and the detailed justification and comparison of these alternatives both individually and in combination.

5. Systems Design -- development of design plans for the circa 1972 military BLHC Systems and identification of R&D programs which will make contributions to the military BLHC System circa 1975-1980.
6. Presentations and Reports -- preparation of the findings of this 12-month study.

Figure 1 graphically describes the process and the interrelationships of all the study tasks within the systems analysis framework. As the model indicates, data gathering activities represented the major allocation of total study resources.

The initial project tasks, the assembly of a broad range of data on the present BLHC System, were required for a characterization of the military BLHC environment as it actually exists rather than as it is understood to exist. And throughout the study, this data intensive approach has left the audit trails vital to future productive efforts.

The BLHC System can be characterized as a comprehensive health care system. While it mav have some elements of a specialty or regional referral system, it always provides a broad array of primary and short-term acute health care. In this sense it differs from most civilian community systems with their pattern of local private physicians' offices, group practices, and multi-specialty clinics which are coupled with small community and large regional hospital centers.

Compared to a civilian system, the military system is much more susceptible to change and growth; mission changes which alter the population mix or cause extreme demands for growth are common and have been generally unpredictable.

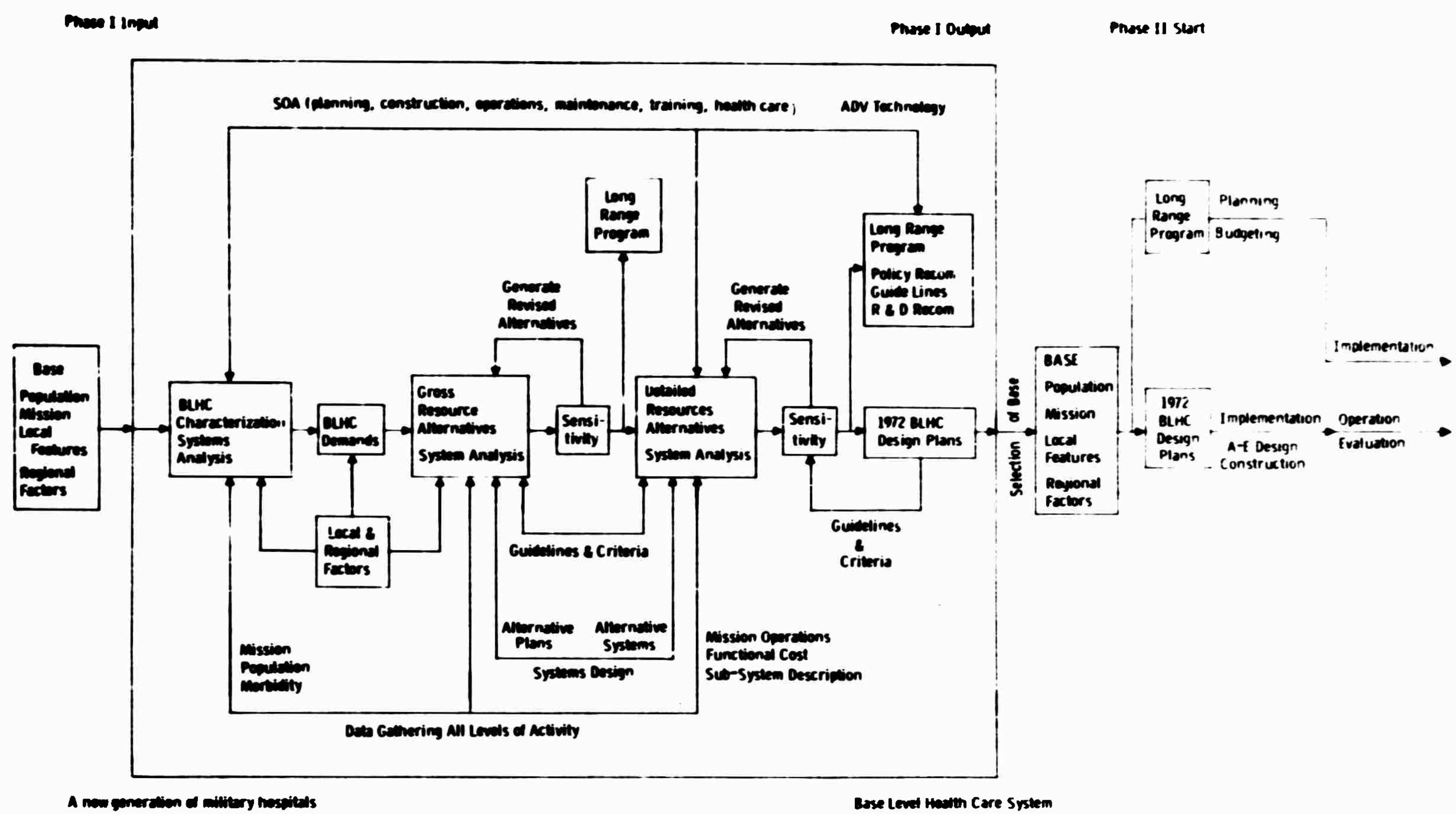


FIGURE 1: HEALTH CARE SYSTEMS MODEL
SHOWING PROCESSES AND INTERRELATIONSHIPS OF ALL STUDY TASKS WITHIN THE SYSTEMS ANALYSIS FRAMEWORK

STUDY CONSTRAINTS

Several constraints were imposed by the Department of Defense on the conduct of this Phase I study, A Systems Analysis Study Towards a "New Generation" of Military Hospitals. These constraints were:

- Alternative systems designs should be developed to serve military base communities with the DoD specified hospital capacities of:

Beneficiary Populations	Beds	Outpatient Visits per Year
40,000 - 50,000	250	300,000
60,000 - 80,000	500	450,000
80,000 - 100,000	750	650,000

- Studies should be limited to services provided at only the base level, i.e. primary hospital plus associated health facilities and dispensaries.
- Regionalization concepts above the base level should not be investigated.
- Disaster planning for natural disasters or mass evacuations should not be included.
- The alternative systems design will not assume relationships for shared services between the Base Level Health Care System and contiguous civilian or other non-DoD related health care facilities.
- The proposed systems concepts must comply with the appropriate governmental and non-governmental agencies regulations and policies pertaining to legal, professional and institutional considerations . . . such laws and regulations should be identified as constraints but should not be limiting in the development of proposals for new and improved operating procedures.

PROBLEM IDENTIFICATION

The fundamental fact which emerged from the study was the uniqueness of each individual BLHC System. Every System has different demands and performance requirements. Based upon that understanding, need for improvement became apparent in three basic areas of the system -- in planning, facilities design, and operations.

1. In planning, a need for a better method of predicting the changing demands a BLHC System must satisfy over its life cycle. Traditional planning methods had too often led to understated resource requirements and unmet health care needs. Needed was a tool to forecast health care requirements at various times in the future, a tool which would also convert those forecasts into specifications of the health care resources required.
2. In facilities design, a need for a system design concept which can respond to health care needs not only initially, but after significant changes and substantial growth. Present designs can rarely absorb rearrangements or modifications in response to new technology nor can they absorb the sometimes abrupt, and often large, expansions required by mission changes. The results have been facilities used in ways that were not intended, and costly modifications and expansions after systems had reached a point of saturation.
3. In operations, a need for resource management and for evaluating the array of sub-system or functional improvement opportunities (such as communications or dietary systems) which are already operational, or which are likely to be in the near future. An extension

of this need for evaluating sub-system alternatives was a method or framework for bringing the many alternatives together in the best combination for the optimal working of the system over its life cycle.

The primary focus was on providing a comprehensive approach for the overall system and sub-systems, with the knowledge that detailed problems can only be resolved within a sound overall framework.

RESULTS AND CONCLUSIONS

The study yields are presented in the following five areas:

1. A massive data resource on health systems in general and on the BLHC System in particular.
2. A demand model -- a method for translating BLHCS beneficiary population data into a statement of the health care required for those populations.
3. A design concept -- a facility organization that will provide a framework for operations and for change and growth over the life cycle.
4. Cost/benefit analyses on major health systems functional areas such as communications, dietary, and materiel handling.
5. Recommendations on medical care.

None of these yields is separate; to some extent they describe the process of the entire study, the path the Westinghouse group took in learning, conceptualizing, analyzing, and testing. Nor are they necessarily in sequence; they are sometimes parallel, often interactive. They are presented separately to dramatize the fact that the sequence described -- planning, design, and operations -- can be performed over a period of time by different groups. The improvements and tools can be implemented and evaluated in toto or individually. And the careful audit trails provide continuing growth and development of all study yields.

The objectives described in the RFQ and Westinghouse commitments made in its proposal have been met, and more. In several instances during the study, Westinghouse has even contributed the use of proprietary software programs and other Corporate resources to further study goals.

The yields from the study meet the three categories of needs previously described with pragmatic and effective solutions.

- The responsive Westinghouse concepts for the NGMH can accommodate new ideas, changes in policy, changes in health care trends, as well as identified performance requirements.
- Planning and design tools developed are generalized solutions adaptable to any BLHC System. These concepts can respond to the uniqueness of every BLHC System.
- Planning and design tools can reduce the time between planning and occupancy.
- These concepts are not confined to the BLHC System; they will also be widely applicable by HEW, civilian hospitals, and the Veterans Administration.
- Many of these study results are not limited to new facilities, but have immediate appli-

cation to retrofit situations both inside and outside the BLHC System.

- Individual operations analyses have produced viable recommendations for the major subsystem areas.
- Medical care recommendations have balanced and guided engineering outputs throughout the study.

2. RECOMMENDATIONS

The recommendations resulting from the successful completion of the Department of Defense Phase I study — Systems Analysis Study Towards a "New Generation" of Military Hospitals, are summarized as follows:

	Source
• Proceed with Phase II implementing and evaluating the results of Phase I. The DoD should regard Phase II as a comprehensive and continuing R&D program, managed through planning, design and operations as a single and consistent process, without discontinuities in time and responsibilities. The same interdisciplinary approach which has proved successful in Phase I should be employed.	Volume I pg. 9
• DoD should establish a full-time interdisciplinary group to participate with industry in Phase II. This DoD group would be the new cadre of health care system planners who will become the core group for a larger staff necessary for the design, construction and operation of the "New Generation" of military hospitals.	

The following recommendations have immediate applicability in all DoD existing facilities and should also be incorporated in the "New Generation" of military hospitals. These recommendations do not require Research and Development (R&D) efforts for implementation.

	Source
• Military careers should be made more attractive and competitive with civilian opportunities by expanding continuing education programs using self-instructional and multimedia aids, and provide opportunities for attending professional meetings and short courses, and developing a peer audit review system with assistance from the Joint Conference Committee of the American Medical Association.	Volume II pp. 3.3-150 to 172 Volume III pp. 33 to 54 Volume IV pp. 3-201 to 218
• Utilize a manual materiel handling system with exchange cart; the automated Power and Free materiel handling system should be considered for 200-300 and 700 to 800 bed BLHC Systems. • Large-cross-section pneumatic tubes should be installed to accommodate high-volume, high-frequency trash and soiled linen removal. • Investigate the use of automatic dumbwaiters for limited use in high-volume, high-frequency, non-level workload areas such as conventional dietary systems.	Volume II pp. 3.3-34 to 52 Volume IV pp. 3.232 to 252
• A combination of convenience foods and abbreviated kitchen for each nursing unit should be adopted; revise staffing and design criteria to allow for BLHC System-wide application.	Volume II pp. 3.3-53 to 68 Volume IV pp. 3-180 to 200

	Source
• Standardize clinical laboratory test procedures and equipment for more precise internal management and generation of more usable data for prediction of workload.	Volume II pp. 3.3-69 to 86 Volume IV pp. 3-37 to 57
• Automated clinical laboratory equipment costing over $35,000 should be leased and not purchased.	
• Utilize a staffing criteria to allow a ratio of one dentist to four assistants to three operatories.	
• Expand the practice of four-handed sit-down dentistry.	Volume II pp. 3.3-87 to 100 Volume IV pp. 3-160 to 179
• Increase the use of dental hygienists in preventive dental programs such as dental prophylaxis, fluoride treatments, water-supply fluoridation, and patient education on prevention of dental disorders.	
• Institute "outpatient surgery" as an integral part of the composite facility -- utilizing existing operating room suites, personnel and ancillary services.	Volume II pp. 3.3-101 to 110 Volume IV pp. 3-1 to 36

	Source
• Level the nursing workload by rescheduling from the peak morning hours of 0700 to 1000 procedures such as: Inpatient movement to ancillary areas Admissions/discharges Bed baths	Volume II pp. 3.3-111 to 149
• Employ the unit dose drug distribution with I. V. additive and Auxiliary Clinical Pharmacist for both inpatient and outpatient operations for all BLHC Systems of 200 beds or more. • Introduce a drug information center for 750- to 1000- bed BLHC Systems.	Volume II 3.3-173 to 190 Volume IV pp. 3-264 to 281
• Utilize the double corridor concept for improved staff and patient traffic patterns in Radiology Departments. • Generators equipped to serve several X-ray machines should be used rather than the existing use of one generator to one X-ray machine.	Volume II pp. 3.3-191 to 206 Volume IV pp. 3-307 to 324

The following recommendations for Short-Term R&D, that is research and development programs that can be completed in less than eighteen months, have been identified by Westinghouse.

Source

- The data base for the Demand Model should be immediately extended and refined to show ancillary usage by level of dependency and by specialty clinic visit. The Demand Model's capabilities depend upon the quality and range of available data; this requires that the data and the Model itself be adjusted and updated on an ongoing basis. The Phase I study developed data to enable immediate application of the Demand Model.

- Investigate the implications of the Westinghouse Phase I study yields for BLHC Systems smaller than 250 beds and for specialty or regional referral centers.

Volume II
pp. 3.1-1 to 60

- Revise existing guidelines and criteria for planning, design, construction and staffing to facilitate incorporation of the various technological options and improvement alternatives into design specifications for the "New Generation" of military hospitals.

Volume II
pp. 3.4-1 to 84

	Source
• Investigate initial installation of a central dedicated processor with time-sharing capability having the essential features of: - central processor dedicated to the NGMH system - time-sharing by functions - commonly shared data base with a natural language interface - cathode ray tube for basic input/output media with limited hard copy capability. • Develop specifications for the use of microfilm for the production, storage, and retrieval of such data as medical records, admission, medical summaries and boards and its applicability to BLHC Systems.	Volume II 3.3-12 to 33 Volume IV pp. 3-58 to 126
• Determine the economic break-even point for dietary disposables and evaluate the consequent impact of disposables on the materiel handling system. • Develop specifications for computerized menu planning for more economical purchasing and inventory control procedures.	Volume II pp. 3.3-53 to 68 Volume IV pp. 3-180 to 200
• Develop a computerized, centralized and standardized data-collection system for major elements in the Base Level Health Care System.	Volume III pp. 94 to 101

	Source
• Develop specifications for computerized central appointment systems for clinics and outpatient services which can handle rescheduling, cancellations, and other varying demands upon the system while allowing flexibility for individual clinics.	Volume III pp. 94 to 101
• Provide audio-visual referral communications centers between BLHCS, dispensaries and University Medical Centers for consultation, to reduce the estimated fifty percent of hospital referrals, and to promptly alert hospital staff to the details of more acute problems and permit more rapid communication of health care data.	Volume III pp. 55 to 69
• Implement computerized techniques including automated testing procedures, terminals for laboratory result readout in nursing stations, outpatient departments, remote facilities, communications systems with hospital decision-making centers, disease detection systems, and quality control for the Clinical Laboratories.	Volume II pp. 3.3-69 to 86 Volume III pp. 55 to 69
• Develop specifications for communications equipment for the Clinical Laboratory which can effect adequate and low-cost image storage and retrieval.	Volume II pp. 3.3-69 to 86

Source

- Establish an innovative position of "Barracks Health Master" with training in preventive medicine including communicable disease, safety, and trauma prevention. These corpsmen on the staff of the drill instructor, would be stationed in the barracks of recruit training centers to function with appropriate responsibility and authority. Such a position would reduce visits to dispensaries and outpatient clinics by recruits.
- Adopt the Physician's Assistant concept for all outpatient clinics in new BLHC Systems; utilize the Corpsman Physicians Assistant for clinics with predominate male patients and the Nurse Practitioner for clinics with predominate female patients.

Volume III
pp. 33 to 54

- Reevaluate and revise outpatient clinic staffing and space planning criteria to allow for:
  - Operation of most clinics twelve hours per day, five days per week.
  - Provide two examining rooms per physician for most clinics.
  - Provide office space for physicians outside the clinic.
  - Meeting needs for patient-family education and counseling, including use of multimedia aids.

Volume II
pp. 3.3-101 to 110

Volume III
pp. 55 to 69

- Establish and computerize the Westinghouse "Graduate" staffing procedure to enable Nursing Service to vary unit staff on a daily basis as workload varies.

Volume II
pp. 3.3-111 to 149

Volume IV
pp. 3-337 to 360

		Source
•	Adopt the Modified Nursing Specialist - Unit Manager organization.	Volume II pp. 3.3-111 to 149 Volume IV pp. 3-337 to 360
•	Develop specifications for an education and training concept employing Integrated Media -- a co: .bination of electronic dial access and instructional program management information and control; evaluate the feasibility of installing this system in existing BLHC Systems.	Volume II pp. 3.3-150 to 172 Volume IV pp. 3.201 to 218
•	Evaluate the applicability of the Radiology "Cluster Room" concept to military hospitals.	Volume II pp. 3.3-191 to 206 Volume IV pp. 3.307 to 324

The followirg recommendations for Long-Term R&D, that is research and development programs that require more than eighteen months of effort before completion of the program, have been identified by Westinghouse.

•	Develop nursing procedure time values by type of patient, level of patient dependency and type of nursing skill required.	Volume II pp. 3.3-111 to 149
•	Develop a uniform and comprehensive reporting procedure for all DoD health care services. Among the major findings of the Westinghouse Phase I study were the variety, inconsistency, and inadequacy of existing data and data reporting systems. Variations between service branches are common; inconsistencies occur between services and, within services, between individual hospitals; and data reported are tied to "functional costs" rather than performance requirements.	Volume II pp. 3.1-1 to 58 Volume V pg. 3-1

	Source
• Implement programs to develop automated hospital information hardware and software systems defined by specifications established in the Short Term R&D programs.	Volume II pp. 3.3-12 to 33
• In the area of construction planning, Westinghouse recommends that the DoD develop specific user needs for industrialized building systems, and components throughout BLHC Systems.	Volume II pp. 3.4-1 to 97
• Explore the development of a worldwide health data bank to permit complete assessments of health care trends, the development of preventive medical programs, and to determine health needs and costs on a much more accurate and efficient basis than currently possible. This might be developed jointly by the military services and the Veterans Administration.	Volume III pp. 94 to 101

In summary, Phase I has not only produced tools that have the capability and flexibility for the complete spectrum of DoD hospitals under consideration, but these tools extend the Westinghouse results to far broader applications, such as, retrofit situations.

The many existing BLHC Systems offer a myriad of opportunities for implementation of the results of this systems analysis program. Such retrofits need not wait for the full scale Phase II application for the DoD to realize substantial benefits in time, dollars, and better sub-system operations.

The implications of this study will extend beyond the DoD. As one of the world's largest comprehensive medical health care programs, the DoD BLHC Systems can become a model for large health care systems everywhere.

3. PRESENTATION OF RESULTS

3.1 DATA RESOURCE

The three bodies of data collected throughout the study are presented in Volumes III, IV and V of this report.

- A massive, detailed data base on the BLHC System as it exists, summarized in Data Inventory (Volume V).
- The Medical Health Care Review Team observations on medical practice, administrative and organizational practice, and facilities, found in the Medical Health Care Review, (Volume III).
- The comprehensive assembly of current information in 16 functional areas in the State-of-the-Art (Volume IV).

Data Inventory

The data inventory produced a detailed characterization of the BLHC System, identifying the relative areas of System costs, performance elements, and flow information. This study of the System included an exhaustive examination of the Data Pack, or DoD package of statistics on the nine hospitals selected by DoD as representative.

To establish a complete and first-hand data base on the BLHC System, Westinghouse teams made site visits and in-depth data inventories at the three primary BLHC facilities and brief, but intensive, data inventory studies at the six secondary BLHC facilities. All those data were computer processed and summarized for use in the systems analysis tasks and are available for additional studies in the future.

The data gathering focus was on the following areas:

- Patient flow
- Communications flow
- Functional costs.

Brief examples of the kinds of information obtained and the types of analysis possible with the data are presented in the following sections

1. Patient Flow

Overall patient flows illustrate the volume of ambulatory health care services as compared to inpatient care. The ratio of annual outpatient visits to inpatient admissions in the Systems studied ranged as high as 30 to 1. The emergency facilities function very much like walk-in clinics, and the dispensaries play a significant role as satellite diagnostic and referral units which help to filter and control the flow of patients into the central BLHC facilities.

Additional data also showed that the non-military beneficiary population is making the primary demands for health care. In the outpatient areas of the three primary BLHC Systems, for example, this population receives from two-thirds to three-quarters of all services.

To generate improved relationships between functional areas and services performed, flows were analyzed: patient flows through each of the outpatient clinics, physician flows from outpatient clinics to inpatient functions, and physician flows during inpatient (ward) rounds.

The flow of inpatients to the outpatient clinics and to other services identifies the largest patient flow element, such as those from the wards to food service, and from wards to clinical laboratories, radiology, and pharmacy. These data were used to define major circulation patterns which are a primary organizing element in the design logic.

Patient flows were also correlated to level of dependency. Two types of significant patient traffic relate to the unaided movement of light-care: ambulatory patients to such areas as dietary, physical therapy, and clinics, and, of course, the highly sensitive patient flows between the wards, surgery, intensive care, and emergency. These observations illustrate the sequences of patient care and the appropriate organization of services for each level and sequence of care.

2. Communications Flow

The data collection also focused on characterizing all important communications flows within the three primary BLHC Systems, including types and volume of communication; time required to prepare these data; time required to transmit the data; and several other key parameters required to assess the nature, value, and cost of communications.

Although the data developed a clear description of the communications flow paths, a significant finding of another kind also emerged. The manual communications system, utilizing "free" patient couriers, results in delays and losses which seriously diminish overall system efficiency.

Assessments of the communications paths reveal that communication problems are likely to occur in areas with large volumes, such as Medical Records Department, Clinical Laboratory and Outpatient Department, also suggesting adjacency problems. At one typical facility, for example, 40 percent of the communications were from requests for laboratory tests and results. These data helped in quantifying the performance requirements for an automated system.

These are just a few examples of the data used to determine the costs of communications, to define the operational characteristics of the BLHC Systems, and to suggest improvement alternatives for solving basic sub-system problems.

3. Functional Costs

Significant effort was spent deriving functional costs for each major component of the BLHC System. These costs, presented in a uniform format to facilitate analysis, provide a base point against which to measure improvements. The compiled costs provide considerable flexibility for determining such items as the cost of medical personnel used in major non-medical areas, such as on-the-job training and housekeeping.

During functional cost preparation, all cost data were prepared so they could be decomposed and reaggregated to provide the supporting data for analyzing improvement alternatives. Audit trails were carefully created. To ensure accuracy of personnel costs, hospital records of employed personnel were compared to the personnel observed by Westinghouse, and all other categories of cost were reviewed in a similar manner. Costs were also expressed in terms of the level of care given each patient — intensive, heavy, moderate or light — for each day of his hospital stay.

The Data Inventory has been vital to the process of the study as a stepping stone to the systems analysis. But further, it is a rich information resource on the existing BLHC System and will continue to be important as baseline data against which to measure future accomplishments.

Medical Health Care Review

The same can be said of the second body of data collected during the initial months of the study, the report on medical practice by the Medical Health Care Review Team. Composed of medical, dental, nursing, and hospital administration personnel, this Team brought a broad range of expertise and background to a brief study of the three selected bases. Medical Team inputs provided data, and were a critiquing resource which complemented engineering inputs throughout the process of data gathering and evaluation. Team contributions helped to spotlight problems and opportunities for medical and organizational improvements within the BLHC System and Team knowledge supplied much backup information for the State-of-the-Art and for subjective evaluation of improvement contenders.

State-of-the-Art

The third body of information assembled in the study, the State-of-the-Art, should have equally diverse application as those of the Data Inventory or the Medical Health Care Review Team. This comprehensive volume, drawn from the broadest and most diverse sources, covers 16 functional areas which represent more than 90 percent of costs of health systems in general. The information in this Volume can make important contributions to retrofit situations within the BLHC System as well as to the New Generation; and it should also be valuable to all other health systems, including the Veterans Administration, HEW, and civilian systems.

The 16 functional areas covered in the State-of-the-Art are:

1. General Medicine
2. Clinical Laboratory
3. Communications and Data Management
4. Construction
5. Dentistry
6. Dietary
7. Education and Training
8. Maintenance and Housekeeping
9. Materiel Handling
10. Multiphasic Testing
11. Pharmacy
12. Physiologic Monitoring
13. Planning
14. Radiology
15. Sterilization
16. Ward Management

In most of the 16 areas, existing hardware or programs could be found to match the BLHC System needs revealed in the study. Most improvement contenders for the subsequent functional analyses were drawn from the State-of-the-Art; other contenders were synthesized or created after deficiencies in existing technology had been identified.

The three parts of the data resource provided Westinghouse with a detailed characterization of the present BLHC System and a broad understanding of existing and projected sub-systems throughout the field of health care delivery -- a necessary and fruitful first step of the "New Generation" study.

3.2 DEMAND MODEL -- A TOOL FOR PLANNING

The second major yield of the Westinghouse study is the Demand Model, a predictive tool which allows DoD to describe the care requirements for a specified base mission and beneficiary population.

This tool replaces historical workload as a method for planning. The study showed that historical workload allows a saturated facility to perpetuate itself as a saturated facility, even after expansion. Missing is measurement of the population to be served and measurement of unmet health care demands.

The Westinghouse Demand Model supplies a superior alternative to historical workload as a planning method. It allows planners to use the known population to predict their potential health care demands. Information on demands served at health care systems other than the BLHC System provides additional information from which to predict demand. The patient care requirements implied by these demands allow facilities designers to match them with health care resources in terms of facilities, sub-systems, and staffing patterns.

The inputs to the Demand Model are base mission, regional factors, the number of recruits, active duty personnel, dependents of active duty personnel, and dependents of retired personnel.

The major outputs of the Model are:

- Inpatient admissions per year by beneficiary category
- Bed census by level of care
- Total number of births per year
- Total number of outpatient visits per year by beneficiary category, with distribution to specialty clinics
- Demands on the ancillary services, such as radiology, clinical laboratories, and pharmacy by inpatients and outpatients.

During the study, the Model was enlarged and adapted to planning for a BLHC System by incorporating such inputs as:

- Extensive examination of the military medical system through observation and data collection.
- The specific data requirements needed by system designers.
- Awareness that perceived, as well as actual, ailments consume health care resources.
- The views of experienced system analysts on methods of modeling the dynamics of health care.

In a classic economic model the population represents a consumer of health care resources, and the BLHC System a source of supply. The Demand Model, shown in Figure 2 interpolates between these two the dynamics of seeking and receiving health care. It does so on the basis of historical age/sex specific demands and utilization.

The population at or around a BLHC System varies according to the service and the base mission, shown in Figure 2A. The population at an Air Force SAC Command Base, for example, differs from that of a Navy base with a recruit training mission by such factors as the ages and duties of the military personnel and the number of their dependents. Population characteristics also may vary according to region, since dependents of active duty personnel, and the retired and their dependents, may settle in a base area because of its location or climate.

The specific categorization of population chosen reflects distinctive demands and patient care requirements. A population tree representing the overall age-sex breakdown of the beneficiaries in CONUS is shown in Figure 2B. Recruits, though they represent only about 2 percent of the total, have been separated from the active duty group because they have unique health care problems. A portion of the population tree represents the active duty population composed primarily of young men

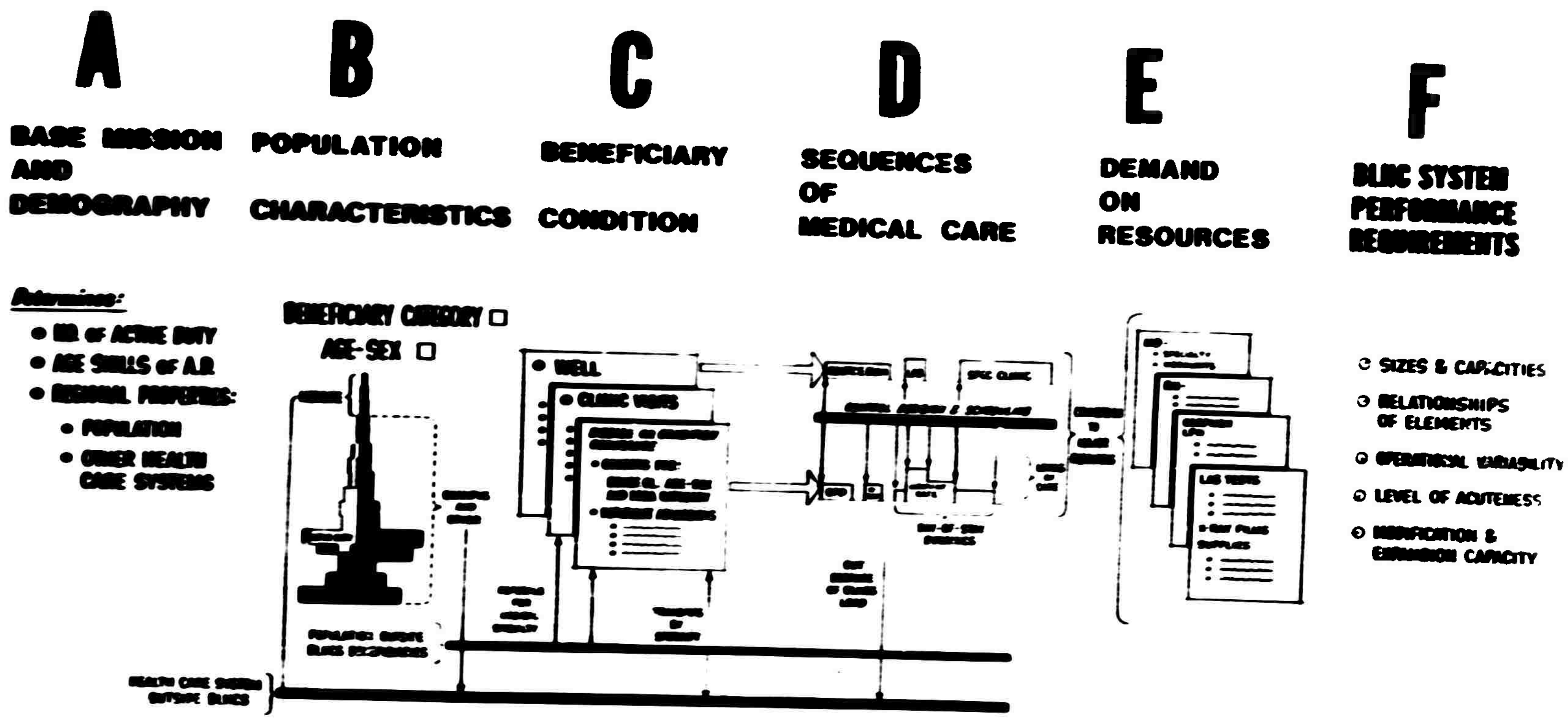


FIGURE 2. THE WESTINGHOUSE DEMAND MODEL

between 20 and 25, with recruits eighteen and up. Because a marked fall-off occurs due to retirements at about age 40, this part of the tree shows a young population not yet suffering from circulatory diseases of middle age. The dependents of active duty personnel represent large obstetric and pediatric components. The retired population component includes both retired military personnel and the dependents of retired and deceased; although extremes of age appear, most of their children are teenagers.

Those beneficiaries authorized for health care have conditions which are not only episodes of illness but also include the "well" condition with routine examinations. In seeking care for these conditions the non-military beneficiaries may refer not only to the BLHC System but to the Civilian Health and Medical Program for the Uniformed Services (CHAMPUS). Beneficiaries over 65 may join MEDICARE. The total of those who use the BLHC System constitute the demand on it.

The health care received over time by an individual is his sequence of care, shown in Figure 2C. From an assemblage of these sequences of care, a dynamic picture can be developed of the sequence and timing of events related to professional services and care delivery. Aggregated profiles of these sequences of care determine the average rate of health resource usage -- the patient care requirements -- of the beneficiaries (Figure 2D).

Westinghouse has collected data on inpatient sequences of care, which include level of dependency of the different categories of beneficiaries and ancillary usage by day of stay. Aggregation of these data then gives the average census in each level of dependency; the sequences allow a close study of shifts required in ward staffing. The use of ancillary services, aggregated to requests per admission, yields a prediction of the load on these services. Because the inpatient record is separate from the outpatient record, only aggregated data on outpatient visits and ancillary usage were collected. These aggregated statistics give the average rate of usage of health care resources (Figure 2E).

An example of the aggregated statistics is shown in Figure 3 with each branch of the tree a ratio. The structure is duplicated for each category of beneficiary; the ratios reflect the patient care requirements of each category.

The population served, projected into the future, determines the patient care requirements for the BLHC System through the Demand Model. These predictions of patient care requirements assist the system designer in setting BLHC System performance requirements (Figure 2F). The workloads on the major sub-systems are determined, allowing a comparison of sub-systems by total life cycle cost. The census in each level of care, and projections of those levels, allow the system designer to match these requirements with sizes and capacity, modification and expansion capability, and patterns of staffing and organization. The fluctuations in each level of care, statistically characterized, further determine the interchangeability required between heavy and moderate care, and between moderate and light care. The load on each major specialty clinic is used by the system designer to arrive at clinic sizes and the relationship of elements within the clinic.

The information from the Demand Model gives the system designer a predictive and precise statement of the patient care requirements for a BLHC System. The structure of the Demand Model allows the ratios in it to be refined as more data becomes available and to be updated to reflect changes in medical technology and practice. By

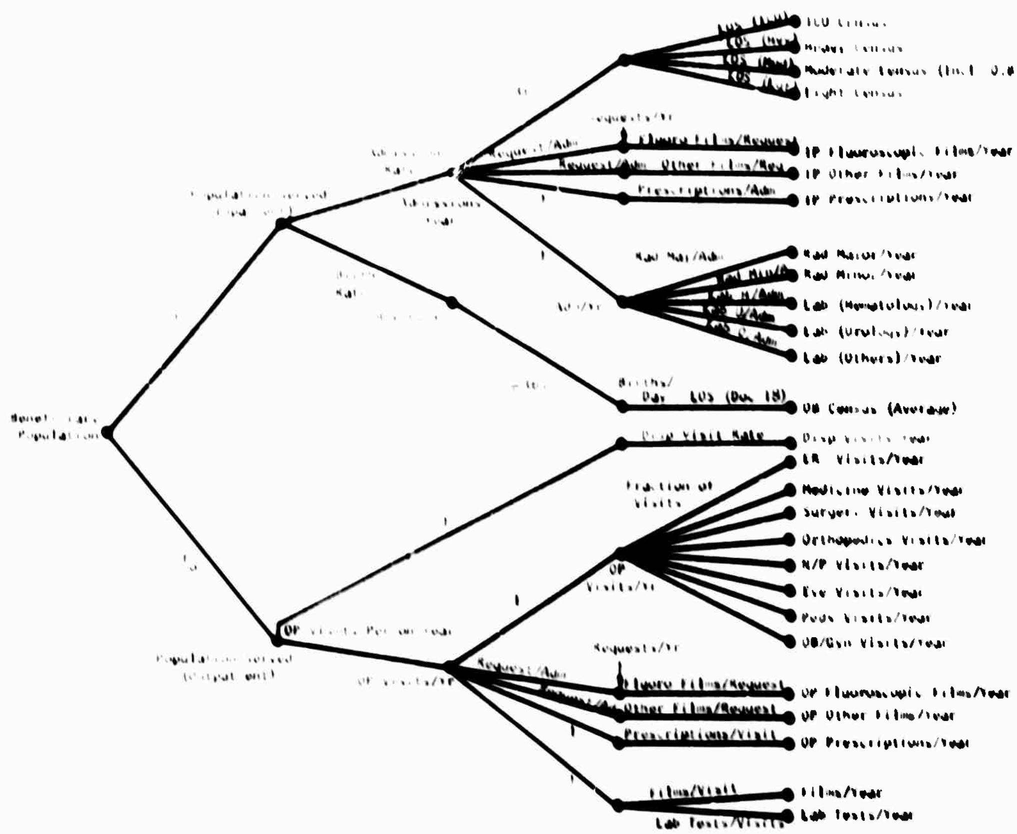


FIGURE 3. WESTINGHOUSE DEMAND MODEL STRUCTURE

varying parameters in the Model, the system designer can perform simulations of changes to determine the impact of the:

- fraction of the population served in either, or both, the inpatient and outpatient areas
- reduction of length of stay in light care through improved disposition procedures
- varying rates of ancillary usage to reflect trends in medical technology and practice
- varying rates of admissions or outpatient visits to reflect regional or socio-economic influences.

The Demand Model is a tool that DoD can immediately use, refine, and expand to predict patient care requirements for a BLHC System.

3.3 SYSTEMS DESIGN CONCEPTS

Introduction

The specific role and objective of systems design in the overall systems analysis is to:

- Generate a design logic which is responsive to the life cycle performance requirements of a BLHC System in terms of changing demands and operational dynamics
- Provide a framework for testing the sub-system alternatives and incorporating operational improvements
- Generate a design configuration which is a major improvement opportunity on a life-cycle cost/benefit basis.

Based on the detailed characterization of the BLHC System, a new design concept has been developed, which is responsive to the wide array of health care demands and missions any BLHC System might need to satisfy over its life cycle. The design concept interfaces with the Demand Model outputs of resources definition and performance requirements. These are defined as follows:

For Any Base Mission and Demography	BLHC Performance Requirements
Population characteristic	Size and capacity
Beneficiary condition	Relationship of elements
Sequences of health care	Operational variability
Demands on resources	Level of acuteness
	Life cycle change and growth capability

These performance requirements are subject to the following sensitivities:

- Technology Change: including advances in hardware and software relating to system/machine relationships, changes in medical practices, increased health care expectations.
- Mission Changes: involving either gradual or sudden fluctuations in military operations and beneficiary population.
- Policy Changes: effecting health care system utilization and services. These are translated into step function changes caused by new missions.
- Regional Considerations: including available civilian health care capabilities and the region's attractiveness to retired military personnel. The impact of local geographic, social, economic, and climatic conditions on health care needs are unique for each System and impose unique design requirements.

The major opportunity for improvement in BLHC facilities, then, lies in developing configurations more responsive to that basic performance requirement -- the requirement of flexibility to absorb change without disrupting the efficient organization of the system.

Three kinds of flexibility are essential: (1) initial capability, (2) change capability, and (3) growth capability. Initial capability must match the highest state-of-the-art in facilities, equipment and materials to existing health care demands. Change capability must accommodate: (1) day-to-day expansion and contraction requirements of specific functions, (2) function and relationship modifications, and (3) new functions. And growth capability must accommodate large expansions in the system at least cost over the life cycle and must successfully meet the problem of widely varying growth characteristics of different system functions. Based on the past history and sensitivities of BLHC Systems, specific growth requirements have been defined.

Inpatient Area. Growth requirements include: 250 beds initially with 200% expansion, 500 beds with 100% expansion and 750 beds initially through 25% expansion. Within this general framework, the design concept must be capable of a large number of initial configuration options to satisfy the requirements of any system within the 250-750 BLHC System range.

Outpatient Area and Clinical Support Services. Largely independent of inpatient area changes, these areas can use more discrete and unique growth units for each function, in response to accelerated demands. The adaptability of these functions must be maximized by providing facilities which are as universal as possible in their health care applications. They must be as free as possible of fixed physical constraints and flexible enough to use staff and equipment in varying combinations.

Design Concept

The proposed design concept evolved from data and operations analyses and the clear need for more appropriate organization of the major physical and functional elements of the BLHC System. Two assumptions were basic to the conceptualizing process; first, that the patient's level of care requirement should be related to the proximity of appropriate level of health care resources, and second, that resources closely related in sequences of patient care should also be close together physically.

Data gathered provided key information on patient flows such as total patient entry -- both scheduled and unscheduled; ambulatory patient flow; flow of inpatients "relatively well" at admission; and flow of inpatients requiring a high or acute level of medical care on admission.

information was also gathered on sequence of medical care -- from light through intensive -- and the extent to which these levels vary in the general BLHC inpatient populations; zones of medical care intensity and the appropriate resources needed for various care intensity levels; information flow, its urgency, and form; and materiel flow, its urgency, and form.

Patient flow is the most significant of these data areas because it triggers the mobilization of personnel, information, and services to the interface points where medical care is provided. Patient flow is the driving force to which the System must respond in terms of organization, resource requirements, and functional relationships (Figure 4). Further analysis and decomposition of the data leads to the characterization of the flow of patients within the System; this definition then leads to the refinement of the relationships of the patient to the health care resources and services (Figure 5). Based on the analysis and flows, these resources and services have been restructured into major activity zones which reflect an improved organization of the BLHC System.

1. Ambulatory Zone

The ambulatory zone contains all outpatient clinics supported by the ancillary services such as medical records, radiology, clinical laboratories, pharmacy, as well as emergency entry and patient service areas. This zone has the most dynamic requirement for growth and change of the individual functional units as well as for the total ambulatory system. This zone also has the greatest requirement for external access and internal circulation.

2. Medical/Professional Zone

The medical/professional zone contains the highest technology and highest level of patient care areas such as surgery, intensive/coronary care, delivery, nursery, as well as functional areas relating to professional

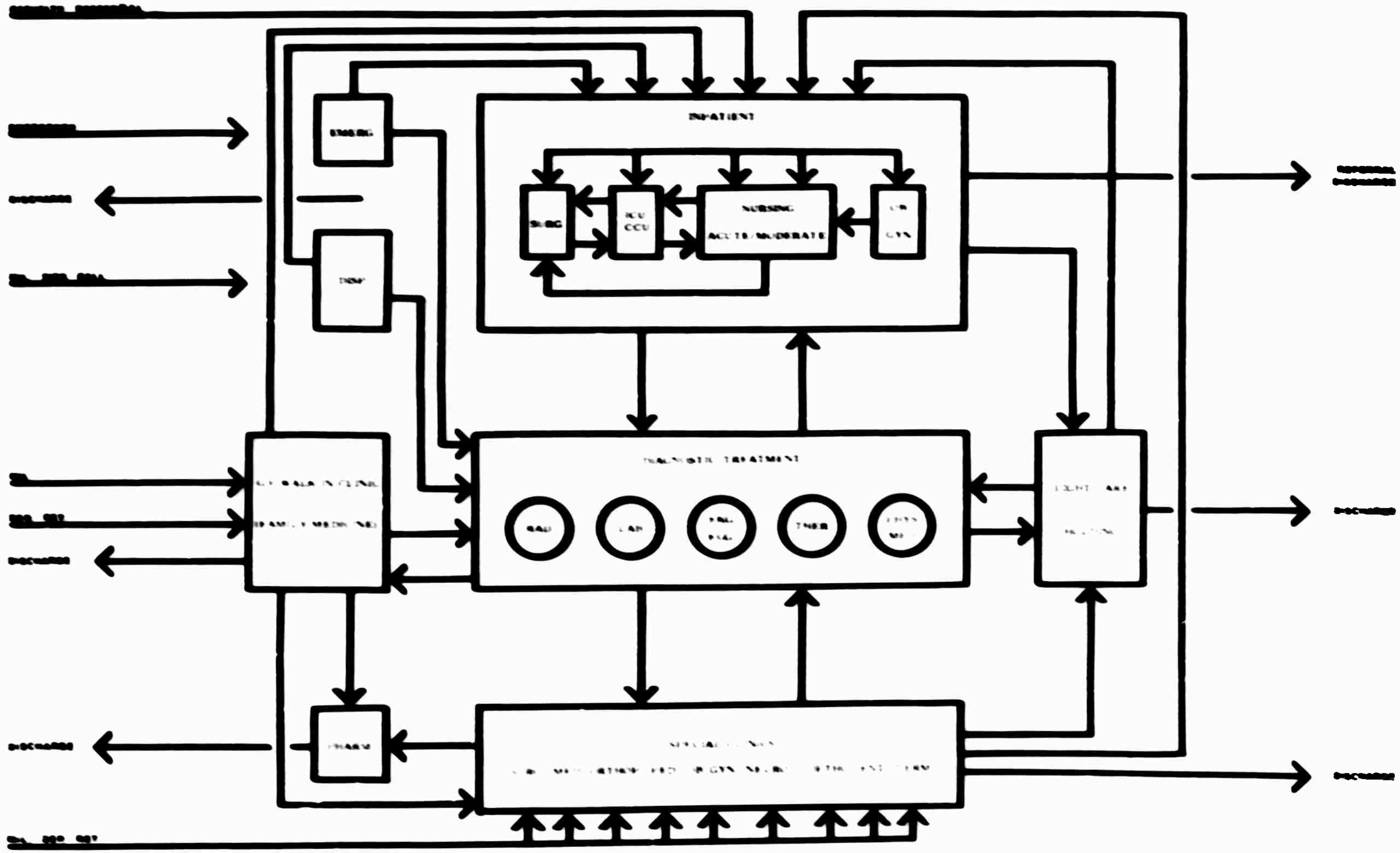


FIGURE 4. SYSTEM FOR PATIENT ENTRY AND FLOW

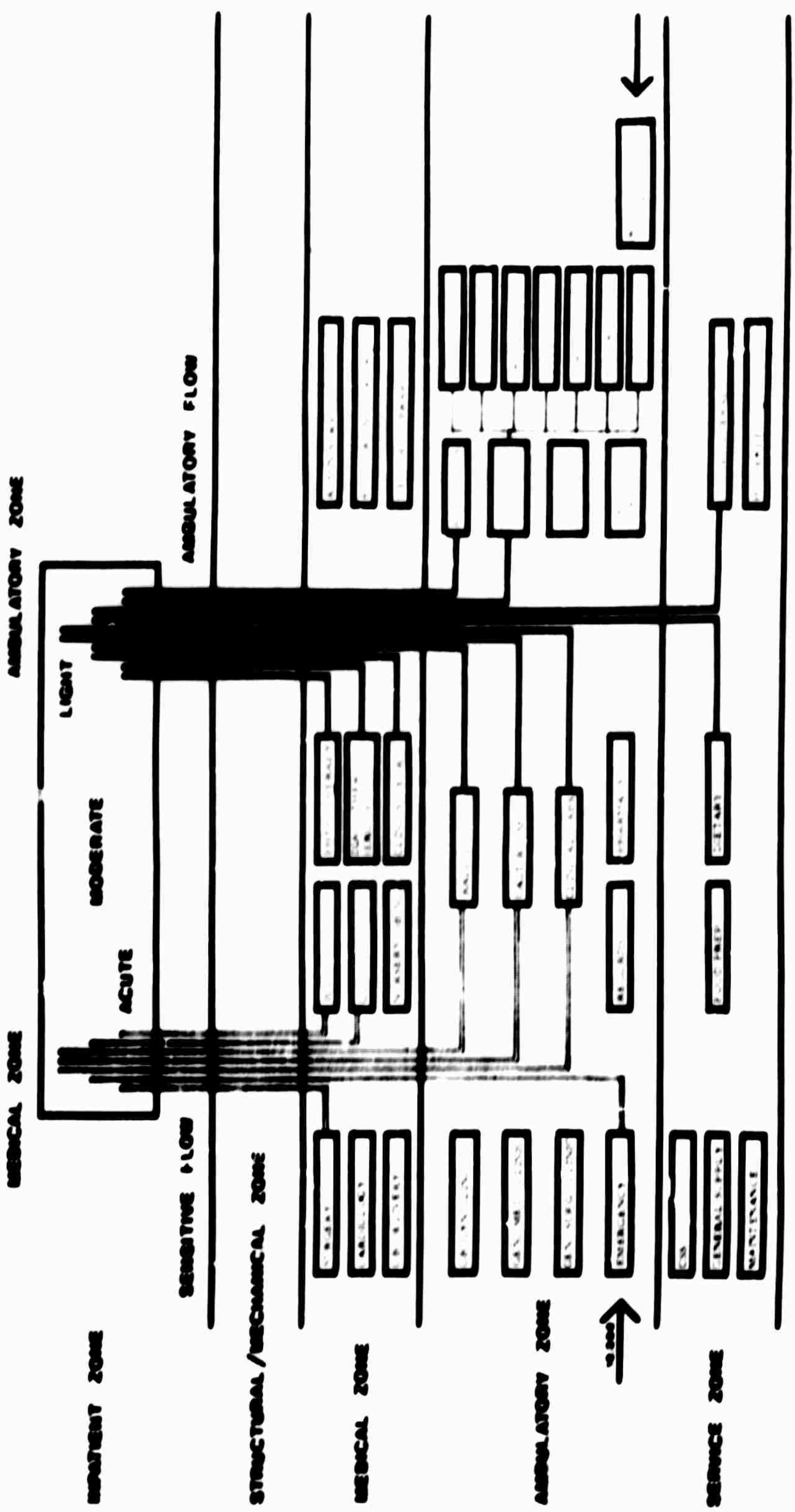


FIGURE 5. INPATIENT FLOW RELATIONSHIP TO THE HEALTH CARE RESOURCES AND SERVICES

activities such as education and administration. This zone has the highest requirement for mechanical and environmental support and controlled circulation. Flexibility for growth needs can be defined in relatively precise modules (two to four more operating rooms, one to two more delivery rooms). The incremental growth of administrative functions relates to the step function growth of the BLHC System.

3. Service and Mechanical Zone

The service and mechanical zone contain major support activities such as dietary, housekeeping, Central Sterile Supply, and the required mechanical and electrical systems. Service activity requires proximity to the inpatient activity, and the mechanical services require ease of access for maintenance and modifications; both must relate to the high technology zone.

4. Inpatient Zone

The inpatient zone contains the nursing activity for levels of dependency ranging from heavy to light care. This zone has moderate needs for mechanical and environmental services. Growth occurs in relatively predictable increments of additional inpatient units from the initial definition within the 250-750 bed range.

Figure 6 graphically illustrates the aggregation of these activity zones into a composite facility, based on the internal and external relationship requirements of the various activities and functional components. The major organizing elements which integrate these activities into an operational framework responsive to BLHCS requirements are summarized in the following paragraphs.

The patient entry system (Figures 7 and 8) relates both scheduled (75 percent of the demand) and unscheduled (walk-in and emergency) demand to the discrete elements of the ambulatory care system. This

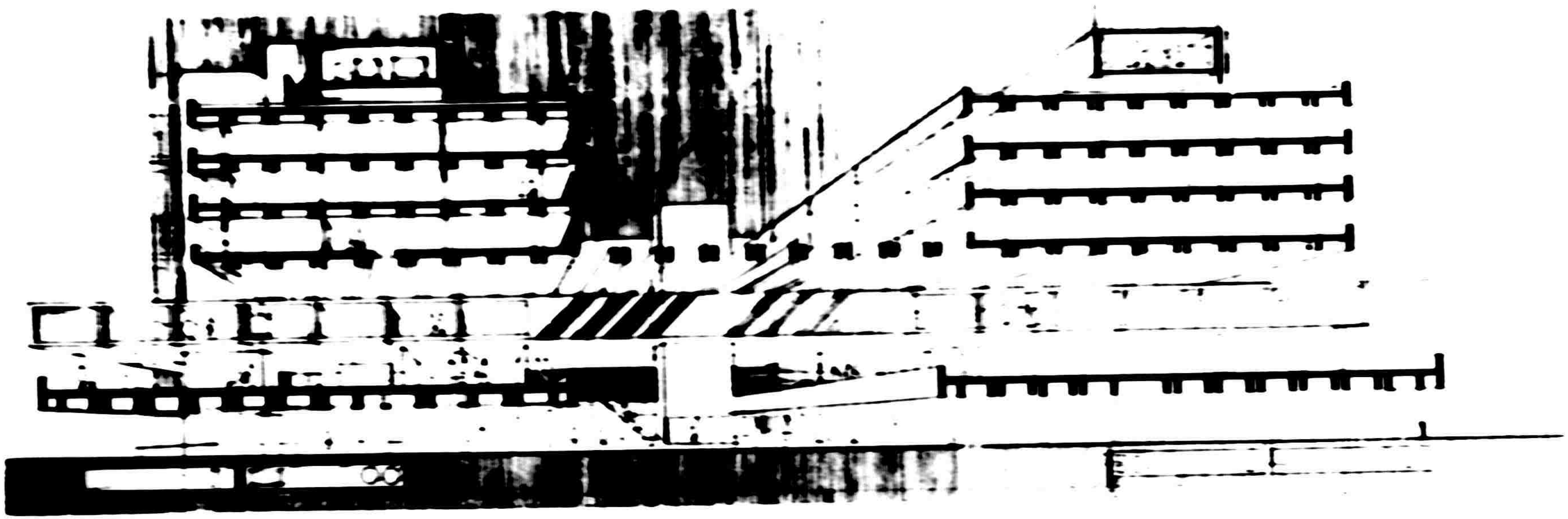


FIGURE 6. SECTION ILLUSTRATION OF THE WESTINGHOUSE DESIGN CONCEPT SHOWING THE AGGREGATION OF THE ACTIVITY ZONES INTO A COMPOSITE FACILITY

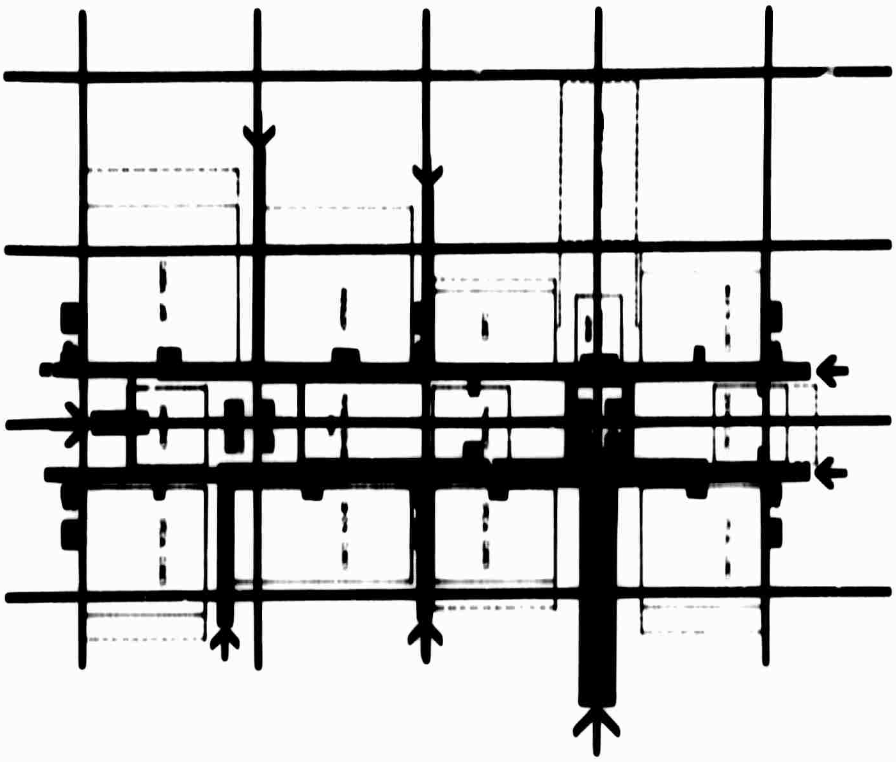


FIGURE 7. TIME/DISTANCE FRAMEWORK SUPERIMPOSED ON THE AMBULATORY LEVEL

FIGURE 8. AMBULATORY LEVEL DESIGN CONCEPT

organizational element permits the most appropriate health care demand-resource interface to occur at the earliest point of the demand. In addition, the individual functional elements have the open-ended capability to grow and change without disturbing the remainder of the system.

A horizontal-time distance framework (Figures 9 and 10) places all functional elements of each activity zone into a framework where individual as well as overall adjacencies can be evaluated. The diagram and model illustrate the superimposition of 140 foot - 1/2 minute walking time grid on the medical and professional zone. This matrix is an appropriate overall framework for the organizational logic. Within the overall matrix, much shorter time-distance relationships are required in specific functional areas such as the emergency system to its supporting diagnostic services.

Primary and secondary circulation and service nodes (Figures 11 and 12) serve as organizing elements which link all the activity zones into an operational framework. The primary nodes contain elevators, stairs, materiel handling system (if appropriate) as well as vertical distribution shafts for utilities and mechanical services. Their main function is the movement of people and materiel; their secondary function is mechanical and electrical service distribution. The main function of the secondary nodes is mechanical distribution, with movement of people a secondary function.

The structural transfer zone (Figure 13) expands the function of the service and mechanical level. The structural loads of the inpatient units are transferred onto long spans, creating large column-free areas for the ambulatory zone and the medical and professional levels. Freeing this level of fixed structural elements allows the most appropriate functional design to be used and flexibility exists for change and modification.

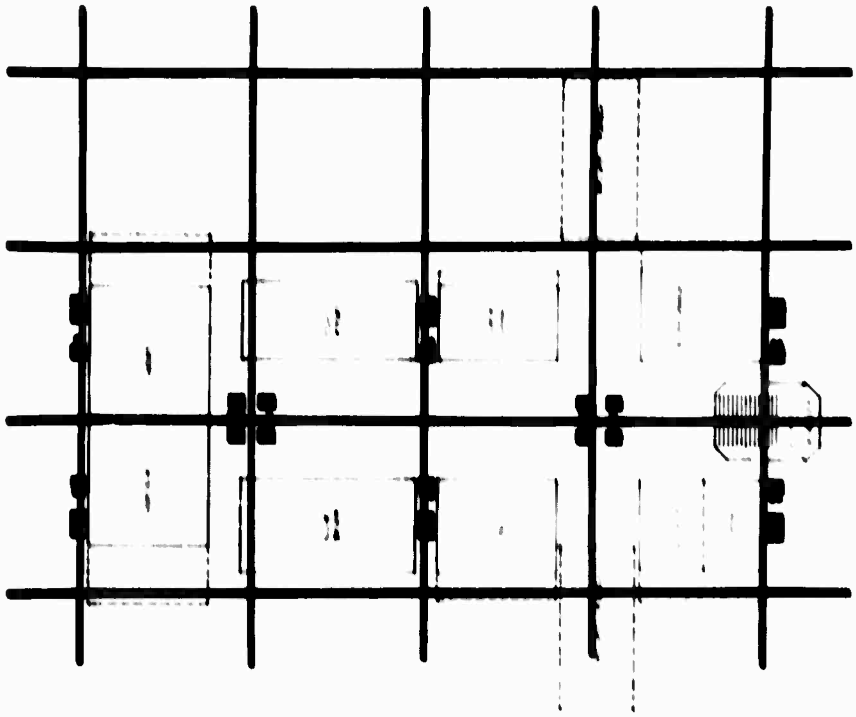


FIGURE 9. TIME/DISTANCE FRAMEWORK SUPERIMPOSED ON THE MEDICAL/ADMINISTRATIVE LEVEL

FIGURE 10. MEDICAL/ADMINISTRATIVE DESIGN CONCEPT

The inpatient system (Figure 14) is designed to accept a variety of staffing and management alternatives. These alternatives relate to intensity of medical activity based on levels of dependency and the progression of the patient through various levels of care. The decomposition of the traditional compact nursing tower into more discrete elements permits a complete range of initial and future configuration options within the 250-750 bed range based on the unique demands of each BLHC System.

The result of the improved organization logic is a BLHC System Design Concept which has the following characteristics:

- A New Building Type
  The configuration is a complete system of health care environments with each major functional activity articulated. It is not static; based on its unique requirements, it can change and grow internally and externally.
- Discrete Responses to Operational Dynamics
  The major functional activities of the BLHC facility -- inpatient, outpatient, clinical, and service support -- have unique and individual capabilities to respond to changing operational requirements and new demands.
- Technology Related to Elements
  The discrete physical elements may each be designed with the most appropriate technology and built with the most appropriate construction techniques. These may include conventional construction as well as industrialized and prefabricated modular components, as they are developed. The growth method permits the inclusion of the most up-to-date technology to be included in the new growth element, thereby reducing the technological obsolescence of the total system.

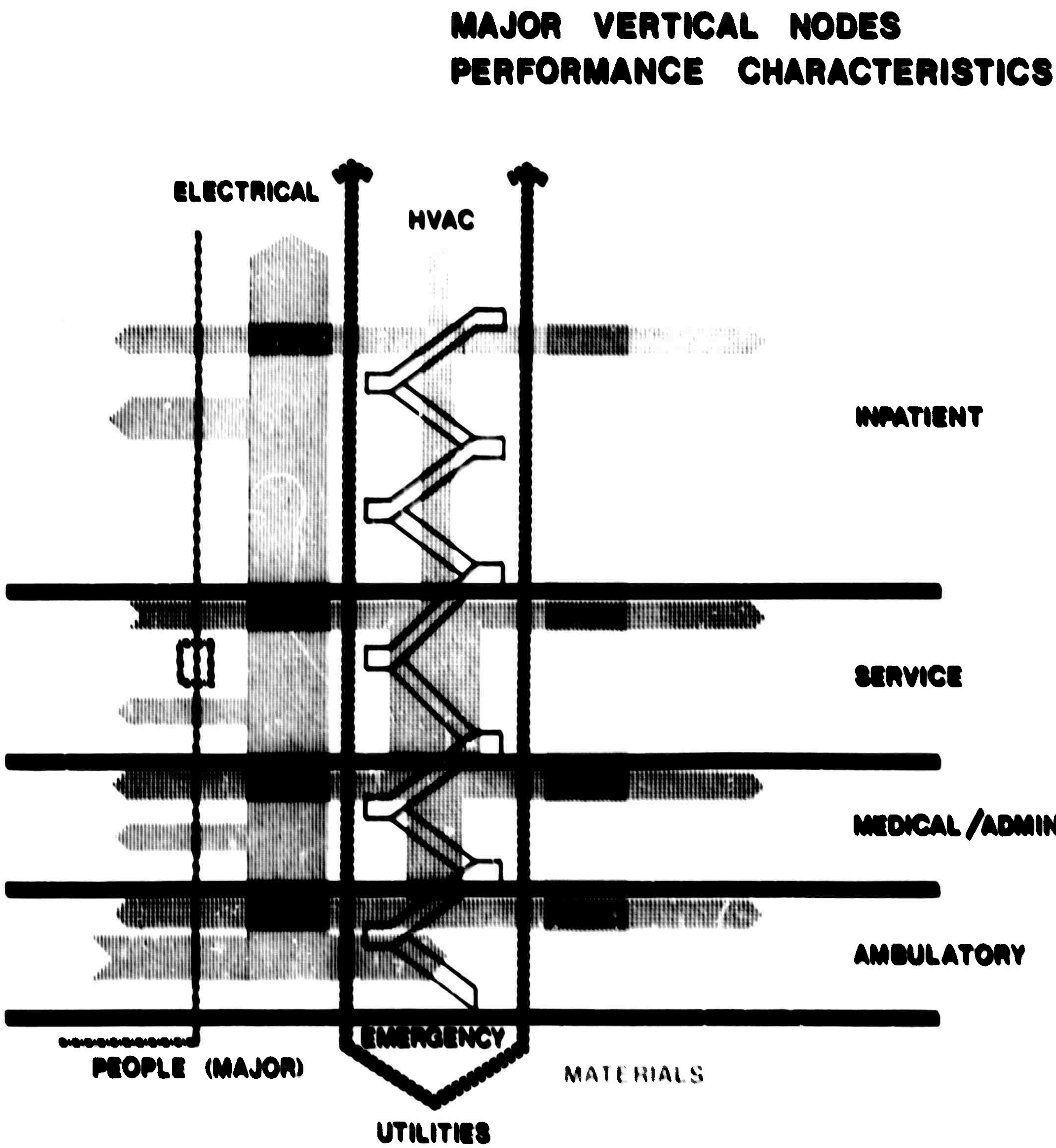


FIGURE 11. MAJOR VERTICAL NODES
PERFORMANCE CHARACTERISTICS

The ten functions studied are:

- Communications and Data Management
- Materiel Handling
- Dietary
- Clinical Laboratory
- Dentistry
- Outpatient Department
- Ward Management
- Education and Training
- Pharmacy
- Radiology

Each function was analyzed by synthesizing alternatives using the Data Inventory to portray the major characteristic of the present method of operation and the state-of-the-art to provide available improvement alternatives. The alternatives were analyzed using present value life cycle costs, or a variation of this method, and reviewed for qualitative advantages. Each recommended alternative was then tested for sensitivity to variations in its major parameters. Because each of the areas is unique in some respects, the following sections briefly summarize each individual improvement analysis and the resulting recommendations. Detailed analyses are presented in Volume II Systems Analysis, Section 3, Operations Analyses.

Communications and Data Management

As the function which binds and coordinates other functions, communications and data management provides patient and resource management information necessary for the delivery of health care. The importance of data exchange, interaction, and manipulation within and between the many BLHC Systems cannot be overemphasized. All management and health care decisions depend, to a large extent, on the availability and accuracy of data.

Three groups of improvement alternatives, described in State-of-the-Art were considered:

(1) Commonly known and used methods, such as messenger, U.S. Government mail, private mail, public address systems, motion pictures, and the conventional telephone.

(2) Medium advanced equipment commonly incorporated into all-encompassing total information networks. Such equipment includes teletypes, intercoms, paging systems, telewriters and facsimile equipment, closed circuit television, and microfilm.

(3) Total information networks, usually computer based, with varying abilities to meet the communications and data management needs of the BLHC System.

Eight total information network improvement alternatives were analyzed:

(1) National Data Communication's REACH
(2) IBM's MISP
(3) Burroughs' "On-line" Medi-data System
(4) Sanders' Communication and Data Management System
(5) Lockheed's MIS-1
(6) Medelco's THIS
(7) ITT Standard Real Time Patient Information System
(8) Computerized Accounting.

From a cost/benefit analysis and a sensitivity study, Westinghouse concludes that significant, directly measurable costs can be saved in six functional areas by displacing manual activities with computer-based systems. The six functional areas -- Ward Management, Outpatient Department, Registrar, Clinical Laboratory, Pharmacy and Radiology --

account for approximately 80 percent of the total communications traffic. The amount of these cost savings are sufficient to justify introduction of computer-based systems. But in addition to these quantifiable cost savings, further benefits include reduced record loss and more rapid record completion.

While it is presently impossible to implement a completely computerized BLHC information network in the 1972 BLHC System because of hardware and software limitations, the capability for a total system should still be built in. Westinghouse recommends, therefore, that initial installation of a central dedicated processor with time-sharing capability be considered. Although this processor cannot be cost justified initially, it will provide the capability for incorporating a complete information network as software and hardware develop.

Any system adopted should use:

(1) Natural language software and a commonly shared data base

(2) A CRT or TV format device which generates minimal hard copy.

Figure 19 shows that both REACH and MISP are cost justified at present for the range of BLHC Systems studied. REACH is recommended because it has a greater capability for meeting the Westinghouse Study Team's criteria of user requirements.

Materiel Handling

Because materiel handling involves transporting and distributing a wide variety of equipment, supplies, and reports throughout the BLHC System, the function's needs cannot be adequately fulfilled by one mode of transportation or one piece of equipment. Instead, several improvement alternatives must be combined.

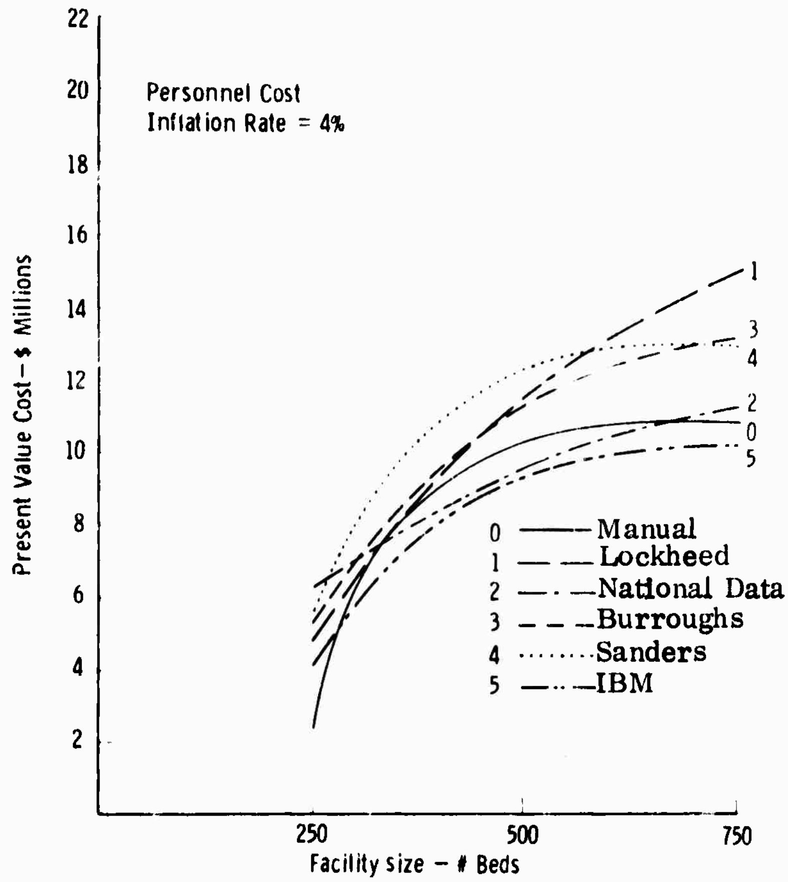


FIGURE 19. BASE LEVEL HEALTH CARE SYSTEM INFORMATION ANALYSIS - 4% INFLATION RATE

At present, all materiel handling in military hospitals is done by personnel who push carts, carry packages, and generally act as carriers and transporters.

Analysis of the data collected by Westinghouse produced several key findings. First, the patient must be supported by a wide variety of interdependent physical transport services which require a wide array of both simple and sophisticated equipment. Second, materiel handling patterns (volume, frequency, and timing) and communications are highly sensitive to hospital configuration, that is, number of stories versus number of beds. Third, selection of materiel handling alternatives is affected by patient mix, walking speed, and the technology level of other functions such as dietary, pharmacy and communications.

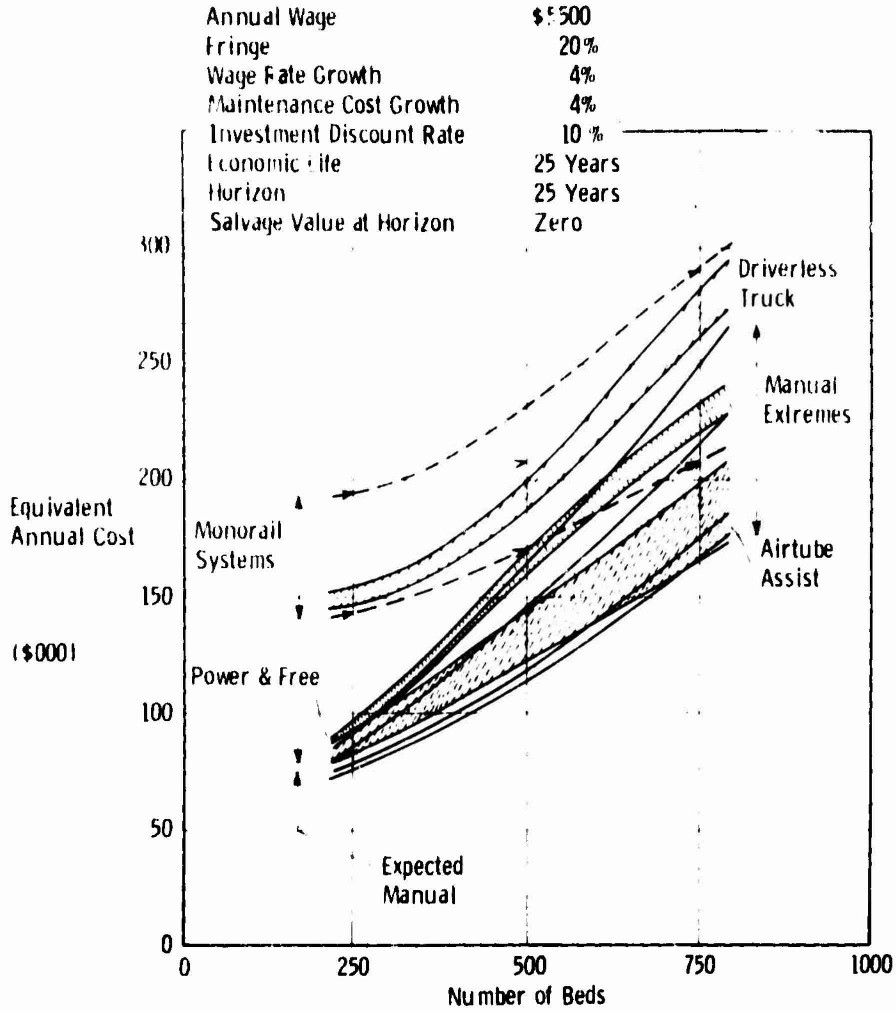


FIGURE 20. MATERIEL HANDLING IMPROVEMENT ALTERNATIVES COST ANALYSIS

Five improvement alternatives which appeared to offer the greatest potential for cost savings were analyzed ranging from the completely manual to highly automated. These are, briefly:

(1) A combination of the best manual approach and exchange carts
(2) Monorails
(3) Driverless truck
(4) Power- and- free equipment
(5) Airtube assist.

Manual materiel handling systems are the least costly and the most flexible for practically all BLHC hospital sizes and configurations. Figure 20 shows the relative annual costs of all alternatives considered.

Of these alternatives, Westinghouse recommends a manual materiel handling system in conjunction with exchange carts for all BLHC Systems.

In addition, large cross-section pneumatic tubes should be installed in all new BLHC Systems to remove high-volume, high-frequency trash and soiled linen. For high-volume, high-frequency, non-level workload patterns, the use of automatic dumbwaiters is also recommended.

Dietary

In a conventional BLHC System, raw foods are converted to finished meals in hospital kitchens and transported manuallv from the kitchen to the wards. Consequently, a disproportionate share of available health care resources are diverted to running and maintaining a restaurant. At the three BLHC Systems studied, for example, 7 to 13 percent of the total operating budget and 9 to 12 percent of the personnel are committed to preparing and serving meals.

Of the alternatives available, Westinghouse selected nine for further study: conventional, convenience foods, catering, abbreviated kitchen and convenience foods, internal manufacture of convenience foods, automated food delivery, computerized menu planning, computerized stockroom information management, and use of disposables.

These alternatives were measured against their ability to reduce costs through more efficient use of personnel and equipment while maintaining quality.

Figure 21 shows the total life cycle present value costs of the alternatives for 250- to 750-bed hospitals.

The Westinghouse Study Team concluded that use of convenience foods together with specially designed kitchens would allow individual meals to be portioned and distributed to the wards more uniformly over the working day, resulting in more efficient use of a smaller staff. Sufficient

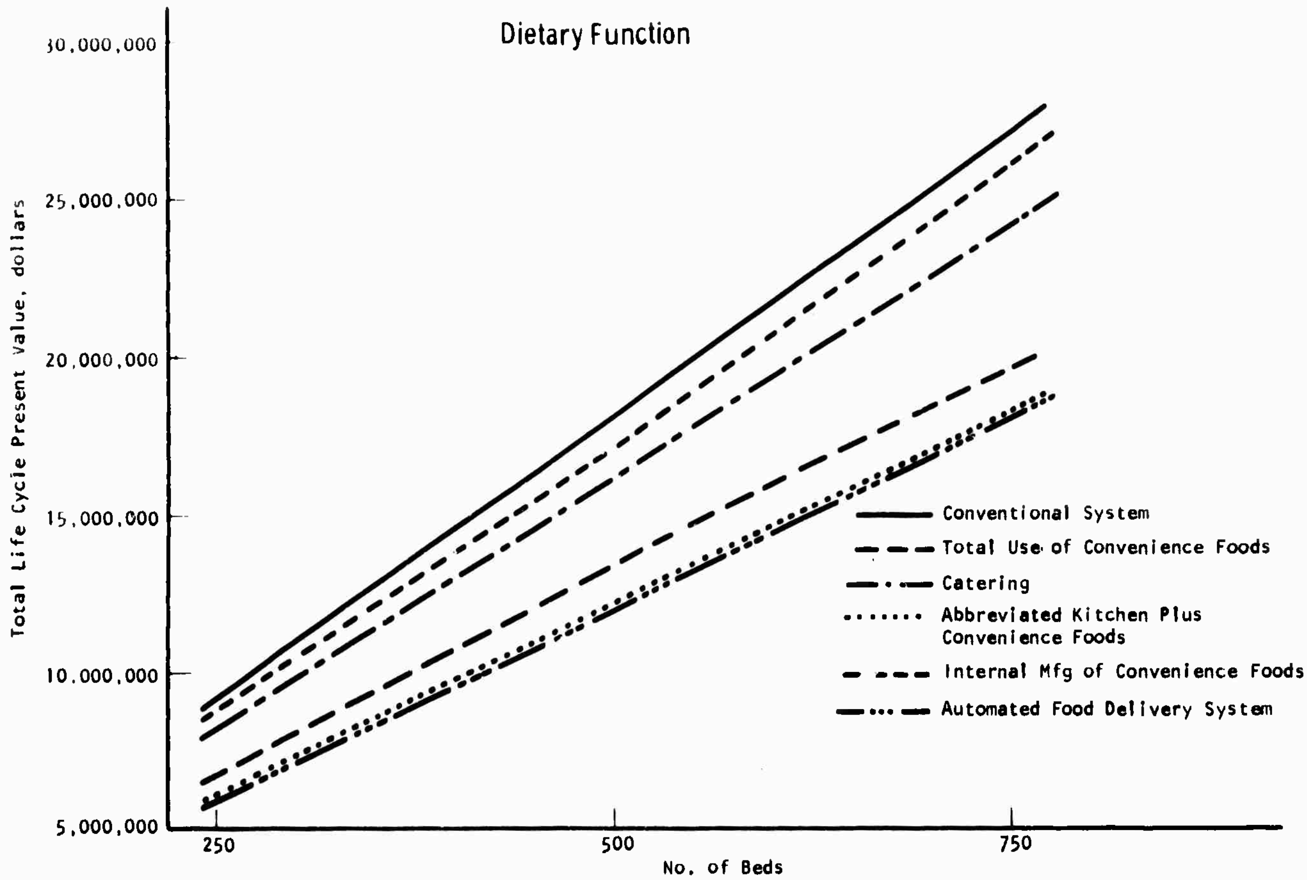


FIGURE 21. TOTAL LIFE-CYCLE PRESENT VALUE COSTS FOR DIETARY ALTERNATIVES.

manufacturers of convenience foods are now available for convenience foods to be used throughout the BLHC System and sufficient logistical capabilities exist in both the military and civilian environments to prevent a temporary dislocation of supplies from jeopardizing a convenience food dietary operation.

Westinghouse recommends an abbreviated kitchen plus the utilization of convenience foods on each nursing unit for all future BLHC facilities. Even though this alternative does not have the least life cycle cost, it is superior to the least cost alternative in terms of simplicity, current feasibility, and sensitivity to changes in patient mix and facility size. The initial investment required would be approximately one-third that required in a conventional system and a 50 percent saving in labor would be realized. Only slight additional equipment would be necessary for reconstituting convenience foods on the nursing units.

Clinical Laboratory

Although the clinical laboratory function only accounts for approximately 4 percent of the total BLHC System operating budget, it is one of the key elements in diagnostic and therapeutic activities. Delays and inaccuracies in this department have repercussions throughout the entire hospital and health care delivery system. Currently, roughly 80 percent of the clinical laboratory operations costs are in personnel, and current design criteria allow for automation of only 35 percent of tests. New technology will not only show a cost benefit through reduced labor or increased throughput, but will provide increased workload capability.

Westinghouse studied all pertinent activities in the test cycle, from the time a physician requests a laboratory test until he receives the results, including support activities such as sample identity and travel during the analysis process.

The primary study objective was to identify the most rapid and reliable method for performing tests regardless of cost. The second objective was a reasonable turn-around time to prevent the time to get test results from being a determining factor in the length of a patient's stay. Third, the possibilities of reducing cost per test were evaluated.

From the State-of-the-Art, nineteen improvement alternatives were selected for detailed analysis and classified into four broad categories: (1) facility design, (2) manual testing, (3) automated equipment, and (4) equipment leasing.

Westinghouse concluded that the operation of the clinical laboratory function between different BLHC Systems is non-uniform in procedures used, degree of automation, accounting and biomedical statistical reporting systems. Despite these disparities, several equipment recommendations were formulated to increase efficiency and reduce operating costs. In addition, test procedures and equipment should be standardized. The method for reporting clinical laboratory data should also be altered to effect more precise internal management and generate more usable data for the prediction of workloads resulting from given inpatient, outpatient mixes, age-sex groupings, and disease incidences. The concept of low cost image storage and retrieval should be evaluated even if a computer-based information or data management system is not to be considered for the overall system. Wherever workload indicates the need for an automated testing device with a purchase price over $35,000, it should be leased rather than purchased.

Dentistry

Dental care consumes approximately 10 to 15 percent of the total operating budget of a typical BLHC System with personnel costs accounting for

90 percent of all dental costs. Any improvement to the dentistry function, therefore, must focus on reducing cost per procedure by increasing personnel efficiency and/or patient throughput.

Stand-up dentistry is now most common, with the slightly reclining patient worked on by a standing dentist, usually with one assistant and one operatory. Sit-down dentistry allows a seated dentist to work on a supine patient, reducing the dentist's fatigue and providing unimpaired work space.

Four-hand dentistry, the natural extension of sit-down dentistry, extends the duties of assistants to providing instruments and performing some routine tasks, freeing the dentist to concentrate on the special dental operations.

Westinghouse evaluated ten improvement alternatives, which covered the ratio of dentists to operatories and to assistant, dental procedures, and facility layout. Studies showed that current military practice underutilizes the dentists. Their productivity could be increased more than 40 percent through revised work practices and through the use of more assistants.

The following table shows the treatment costs and effectiveness of utilizing the ratio of one dentist to three operatories to four assistants over other feasible alternatives.

No. Dentists	No. Operatories	No. Assistants	Restorations per Hour	Cost per Procedure	% Increase in Procedures per Hour over Preceding Alternative
1	1	1	1.25	$9.05	(In present)
1	1	2	1.66	8.70	33%
1	2	3	4.10	4.29	147%
1	3	4	5.56	3.72	35%

Westinghouse recommends that DoD consider standardizing all dental clinic procedures, especially with respect to the introduction of the last alternative. Personnel efficiency can also be increased by replacing individual operatories with the rectangular multiple-operatory for the majority of operating procedures.

Outpatient Department

Outpatient Department (OPD) activities are one of the most labor intensive in the BLHC System; approximately 85 percent of costs are in personnel. Superficially, little correlation appeared between the three primary BLHC Systems studied -- the percentages of total operating budget represented by the OPD function range up to 36 percent; costs per patient visit vary widely; and considerable differences in staff specialty mixes exist. All three Systems, however, have several basic similarities in OPD's -- a faster growing workload than in any other area; almost every OPD facility is saturated; scheduling systems, when available, are generally improperly used; professionals are overburdened with administrative work; poor staff and patient traffic patterns detract from efficient patient processing and resource utilization; and poor flow of data and communications occurs between OPD clinics, records, ancillary services, and the inpatient areas.

It is extremely difficult to select or to analyze operational improvement alternatives that will have an effect on the OPD as a whole. Some of the alternatives selected for study are not amenable to quantification or comparison to the present method for cost justification. In addition, the major improvement is inextricably interrelated to a more effective management of resources based on an improved data communication system.

Five areas were isolated for evaluation and analysis:

(1) Training and use of physicians' assistants

(2) Automated multiphasic testing

(3) Multiple use of clinic facilities

(4) Increased ratio of examining room to physician

(5) Introduction of outpatient surgery.

Westinghouse concluded that several functions which physicians now perform should be performed by an adequately trained Physician's Assistant. Education and training programs within the DoD are practical for producing such personnel. In addition, the physician's time can be more effectively used if he is allocated at least two examining rooms. While more than two rooms per physician may be justified for some clinics, the more specialized facility layouts which would result would detract from multiple usage, which is another Westinghouse recommendation.

The costs and benefits to be gained from automated multiphasic testing are not sufficiently defined or cost justifiable to recommend this alternative at this time. "Outpatient surgery" is both practical and can be cost justified for new BLHC Systems. It can handle approximately 20 percent of all surgical procedures now done on an inpatient basis. It is best introduced as an integral part of the facility, utilizing existing operating room suites, personnel, and ancillary services.

Ward Management

Ward management -- the application of nursing and administrative services to individual wards -- presently represents the largest single personnel cost of the BLHC System.

Using detailed data on the present methods of ward management in the BLHC System, the present staffing method was compared with improvement alternatives relating to (1) estimated gross numbers and types of staff assigned to the BLHC ward management function, and (2) the organization of staffing for ward management functions.

Because of the number and complexity of relationships between operating cost and quality of care, ward management is difficult to evaluate quantitatively; however, there are some areas of potential improvement.

From a detailed analysis of five staffing and five organization alternatives, the Study Team concluded that the Westinghouse "Graduate" staffing alternative be adopted for estimating and authorizing ward management staff currently being utilized for staffing V.A. Hospitals. The time values to be used should be adapted from the V.A. time standard. Additionally, a staffing concept should be adopted which employs a trained cadre of nursing personnel available for reassignment to different nursing units to meet changing workloads. The organization alternative recommended is the Modified Nursing Specialist - Unit Manager concept.

Education and Training

Education and training programs in the BLHC System are usually aimed at personnel orientation, continuing education, or on-the-job (OJT) training. A minor, but increasingly important objective is to instruct patients and their families in preventive medicine and dentistry.

Approximately 50 percent of all BLHC education and training is OJT. On-the-job training demands considerable expenditure of both time and money, reduces teacher efficiency, and produces non-uniform instruction which is particularly difficult to monitor.

Expanding patient care workloads coupled with staff shortages severely limit the time that skilled and professional personnel can devote to education and training. A prime objective of the Westinghouse study, therefore, was to relieve these personnel of repetitive training duties through increased use of electronic and mechanical devices.

Present education and training methods were compared with the following:

(1) Programmed instruction
(2) Learner centered audio-visual devices
(3) Instructional TV
(4) Dial access information retrieval
(5) A combination of teaching machines and sound and motion pictures
(6) Integrated media.

A cost/benefit and sensitivity analysis of the improvement alternatives indicated the integrated media approach to be the most promising.

The predominant cost/benefit justification for use of integrated media is based on a reduction in life cycle cost for the direct and identifiable costs of OJT. Additional economies should derive from more effective utilization of staff freed from teaching duties.

A bonus of the integrated media is its applicability in several fields of education and training other than OJT, thus resulting in further cost savings. For example, the system can be interfaced with reference data and research data banks, permitting data to be more fully distributed throughout the hospital.

Pharmacy

Drug distribution demands in pharmacy departments of BLHC Systems vary considerably according to patient mix and type of medical staff. To determine the appropriate method of drug distribution, Westinghouse considered the following factors:

(1) The way a drug's physical characteristics affects its mode of transportation.
(2) Pricing policies.
(3) The effect facilities and personnel have on drug administration.
(4) Changes in the roles of paramedical personnel.

The basic drug distribution procedure for inpatient areas consists of the nurse or ward secretary sending a requisition for the physician's medication order to the pharmacy. The drug is delivered for storage on the nursing unit and administered until depletion when the procedure is repeated. For outpatients, individual prescriptions are usually presented by the patient at the pharmacy.

A major problem in the use of pharmacy manpower is peak loading. Better scheduling procedures to dispense drugs to inpatients during the slack periods would contribute to leveling the workload.

Ten improvement alternatives were studied:

(1) Ward component drug distribution
(2) Unit dose drug distribution
(3) Mechanical distribution
(4) Automated drug distribution
(5) Intravenous (I. V.) additive program
(6) Clinical pharmacy concept
(7) Drug information center
(8) Pharmacy prescribing
(9) Pharmacy medication administration
(10) Automated outpatient dispensing.

The first four alternatives are total distribution methods capable of handling all the needs of the BLHC System while the remainder are auxiliary methods to be used in conjunction with any of the first four.

Present value life cycle costs were calculated for the four primary alternatives for several sizes of hospitals. For all hospitals above 200 beds, the currently available system with best total present value costs is the unit dose system. The savings between the present methods and unit dose at the three BLHC Systems studied is summarized below:

Hospital:	Beaufort	Andrews	Walson
Ward Component (present method)	$1,276,800	$4,247,244	$5,407,137
Unit Dose	1,156,609	2,408,667	3,219,952
Savings	$ 119,191	$ 838,577	$2,187,185

From its cost/benefit and sensitivity analyses, Westinghouse recommends that the unit drug alternative, together with the I. V. additives and clinical pharmacist auxiliary alternatives, be implemented for both inpatient and outpatient operations for the new BLHC Systems over 200 beds, the outpatient operations should be automated.

The future feasibility of installing the total automated drug distribution alternative should be carefully examined as it becomes available.

Radiology

Radiology represents only a relatively small percentage of the total operating costs of a BLHC System. Nevertheless, its critical role in diagnosis and decision-making affects the total therapeutic process, making it essential to improve the function wherever possible.

While the number of radiology films exposed has been increasing at an average of 12.8 percent over the past three years at the three study hospitals, the number of radiologists has increased only 3 percent per year. This widening gap between demand and qualified personnel has created a need to increase the productivity of the radiologist and his staff.

The Westinghouse study concluded that three areas had significant potential for improvement:

(1) Improving layouts to smooth the flow of patients from their entry into the Radiology department until they are properly positioned for X-ray procedures.

(2) Improving processing and quality control procedures to process film and evaluate quality prior to patient release and subsequent freeing of the machine for the next patient.

(3) Finding methods to relieve radiologist from routine and administrative chores to free his time for more productive film evaluation and assisting in the diagnostic process.

Seven improvement alternatives were examined:

(1) Present methods

(2) Double corridor suite layout

(3) Cluster suite layout

(4) Satellite stations

(5) More automated radiology equipment

(6) More highly trained technicians

(7) Centralized generators.

Based on personnel needed for specific numbers of procedures per day and on data gathered on two-corridor staffing at a Baltimore hospital, annual personnel costs for the present and double corridor alternatives were plotted against daily procedures (Figure 23).

With the double corridor layout in a facility performing approximately 230 procedures per day, annual personnel costs are estimated at $67,000 below present practices. Savings will increase as the number of procedures increase.

The following list shows the initial cost savings that can be realized if centralized generators are installed; no operating savings will be realized with this alternative.

No. Rooms	No. Generators	Cost of 750-mA 3Ø Generators	Switch Cost	Savings
4	4	$80,000	0	
4	2	40,000	$1,500	$38,500
4	1	20,000	750	59,250

Westinghouse recommends the Radiology Department layout be redesigned to accommodate the double corridor concept for improved staff and patient traffic patterns and that generators equipped to serve several X-ray machines be used rather than the existing one generator to one X-ray machine system.

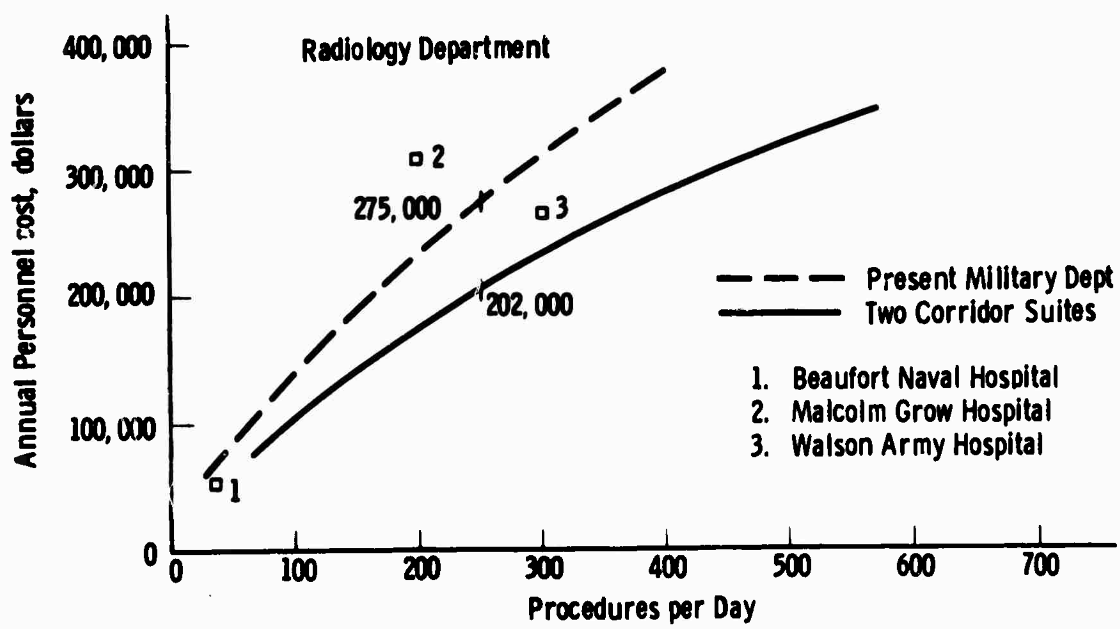


FIGURE 23. PERSONNEL COST VS EXAMINATIONS PER DAY

3.5 MEDICAL HEALTH CARE REVIEW TEAM

The Westinghouse Team fully realized that engineering expertise alone would not be adequate to judge the compatibility, acceptability, and quality of medical practices. Therefore, a Medical Health Care Review Team was formed, composed of seven physicians, a dentist, two registered nurses with doctorates, and a hospital administrator. The role of the Team was threefold:

- Identify current health care needs
- Serve as a critical filter, observing and critiquing the present BLHC System to provide a basis for selecting areas to study and analyze in greater depth
- Ensure that Westinghouse recommendations are compatible with good medical practice.

Based on three-day visits to each of the three primary medical facilities, the Team qualitatively reviewed the effectiveness of health care delivery through interviews and observations. Their resulting contribution is unique in that it forms both a data resource and a portion of the analysis. Their observations and recommendations form a brief, but intensive examination of selected facilities, and interviews with health personnel have highlighted the complexity of the demands upon the system as well as some of the medical factors which will impact upon the design, construction, and operation of the NGMH.

Medical Team members were an integral part of the Westinghouse Team throughout the study. Within the first several months they indicated areas of current practice which required more intensive study and analysis and during the latter months they ensured that the analyses and conclusions for the NGMH were both acceptable and feasible to professional health care practice and personnel.

The consensus of the Team was that the military has a medical staff of high caliber, who provide excellent comprehensive care programs. However, the facilities, which are designed primarily for military patients, are being stressed by the heavy demand from dependent populations. Also, the facilities are not designed to accommodate the large ambulatory care demands which now exceed 50 percent of total services.

One of the primary problems facing the military medical system is the shortage of professional personnel and the high turnover rate which tends to disrupt the amount and types of services available at any specific time. In general, the military health care personnel, particularly physicians, are maintained through the draft law; salary scales and other benefits are often lower than those provided their civilian counterparts. The Team, therefore, focused on recommendations to attract, hold, and upgrade highly skilled professional personnel, since the problem of turnover will increase as competition for these personnel intensifies from the civilian sector.

Examples of some of the recommendations on professional personnel follow. The total report is found in Volume III.

- Within all the professional staff categories greater stabilization of assignments was recommended since frequent transfers were found to adversely affect both quality of care provided and job satisfaction.
- Professional career positions should be made more attractive by expanding the career ladder approach with new opportunities and greater responsibility and by providing wider ranges of continuing education.
- Investigate a core curriculum for corpsmen of all services with a separate portion of the curriculum tailored to the needs and mission of the individual

services. The corpsmen are essential for the support of the system. It is recommended that new career positions be developed to more fully utilize their potential and to utilize physician time more effectively.

- A Barracks Health Master program should be developed to provide a first echelon of medical care for recruits by stationing corpsmen in the barracks of recruit training centers.
- Specially trained nurses and corpsmen should be given greater responsibility in patient care decision making. These "physician assistants" could also be used in dispensaries to minimize physician involvement.
- Clinical careers for M.D.'s should receive more emphasis and encouragement.
- Nurse clinical specialists should be used more fully.

The Team reviewed the BLHC facilities with an eye to evaluating design and resources to increase personnel efficiency and to suggest directions for innovative improvements.

They noted the overcrowded ambulatory medical facilities with poor flow patterns of patients, staff, materiel, and communications. Physicians reported that dispensary assignments were the most undesirable, particularly where they were cut off from the main hospital both by distance and inadequate communication. Furthermore, separate administrative control often creates a gap in the continuity of patient care.

Most of the Ambulatory Care facilities were outdated and poorly designed for patient convenience as well as adjacencies.

The inpatient facilities had been built mainly for male populations suffering from contagious diseases and trauma. Large open wards were common, nursing stations were often poorly located and crowded, and ward arrangement poor, with the most acutely ill patients generally farthest from the nursing station. These problems were inherent in the older facilities observed, i.e., Dix constructed in 1960, Andrews-1958 and Beaufort-1948.

The Team focused on such factors as improved adjacencies, multiple use rooms, and new concepts in dispensaries as well as noting such details as the need for additional storage and office space.

Some of their recommendations included:

- Redesign dispensaries to offer more preventive medicine.
- Tie these dispensaries closely to the BLHC facility with physicians serving both the hospital and the dispensary.
- Extend clinic hours in high demand areas, such as obstetrics and pediatrics.
- Increase the number of multiple-use clinics.
- Emphasize patient education and self-care for inpatients and preventive medicine for outpatients.
- Provide more sophisticated and standardized monitoring equipment.
- Implement computerized techniques including automated testing procedures, terminals for laboratory result readouts, and communication systems with hospital decision-making centers as well as automated medical records management.
- Improve ward management by relating nursing procedures to patient dependency levels.

The Team's study of Professional Services concluded that the health services of the military provide a comprehensive health care program which surpasses the programs offered by most civilian systems.

Their recommendations included:

- Institute a core of surgical personnel to operate as a unit to provide a balance of surgical services.
- Increase flexibility and personnel efficiency in Pediatrics by using pediatric assistants or nurse practitioners.
- Develop a modular treatment center for improved neuro-psychiatric services.
- Develop a Surgicenter concept where minor operations are conducted on an outpatient basis. These are estimated to be able to handle up to 20 percent of the surgical load.

In administrative services, many severe problems were noted in data management.

- A computerized, centralized and standardized data collection system is strongly recommended for major BLHC elements.
- This computer capability should also be used to develop centralized appointment schedules and better overall record systems.

These recommendations represent only a part of the Medical Health Care Review Team's input to the analysis process. Their contribution in screening and balancing the quantitative inputs were indispensable to the success of the total study.

3.6 SYSTEMS APPLICATION (BASE "X")

<u>Introduction</u>

Although the RFQ limited the focus of the study to three sizes of BLHC Systems, Westinghouse believes that arbitrary sizes of facilities are a limiting factor in developing a truly generalized planning and design methodology. A responsive systems approach should be able to determine the health care needs from a population. If a configuration solution of 250 beds with 600,000 outpatient visits per year is indicated, the Design Concept must then be able to respond.

To demonstrate the application and usefulness of the demand model outputs and the design configuration logic, a hypothetical Base "X" was defined with certain assigned life cycle characteristics. The Westinghouse strategy was to select a population in the middle of the range (500 beds to serve 60,000 to 80,000 people). The population components were assumed to be equivalent to the CONUS-wide data in terms of age and sex. From this starting point, each of the several separate study outputs -- the Demand Model, the Design Concept, and the Operational Improvements -- could be demonstrated, interrelated, and justified. The overriding problem in current Systems has been identified as their inability to respond to change and growth. Therefore, this initial population was assigned variations over time which represent the real-life growth of retirees and their dependents, and two separate and major mission changes for the military populations. The populations resulting from these two approaches are shown in Figure 24.

Using this population data for both examples, the study outputs were applied:

- <u>The Demand Model</u> was programmed with the Base "X" population data at each time interval and a comprehensive set of health care resource requirements was obtained.

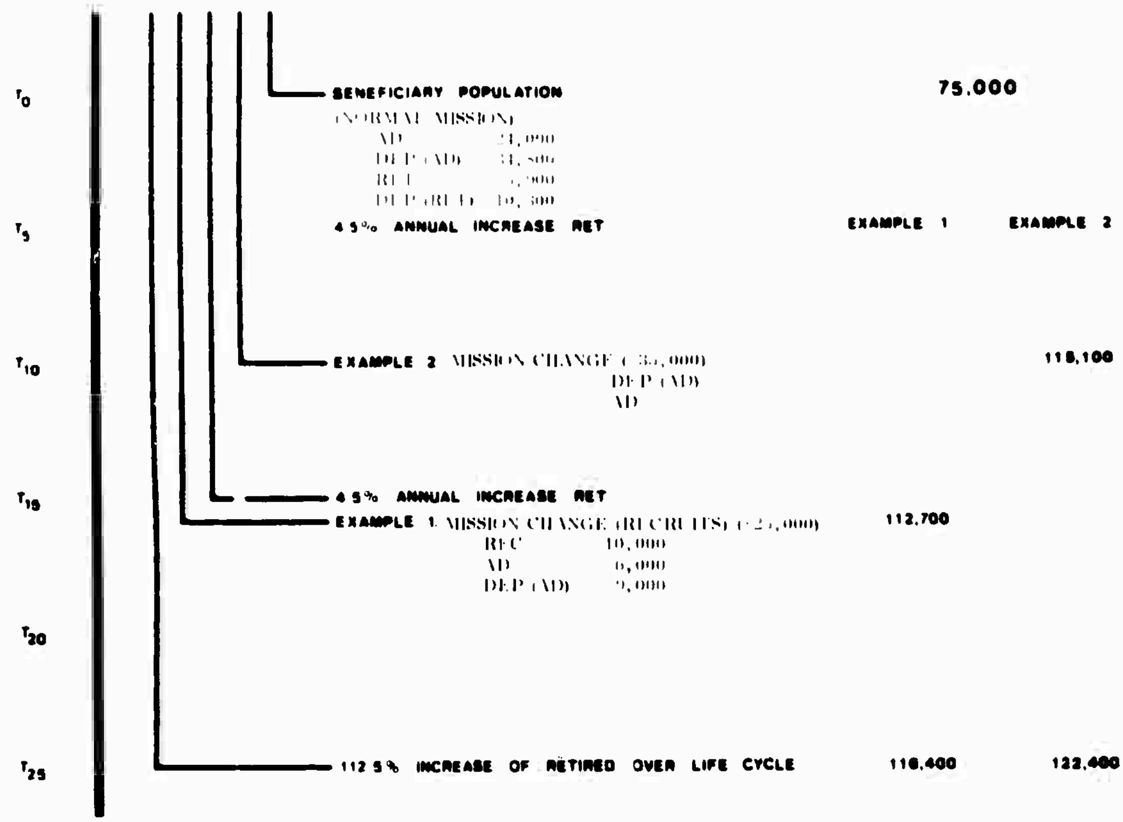


FIGURE 24. DEFINITION OF HYPOTHETICAL BASE "X"

- <u>The Design Logic</u> was used to generate a series of configurations both in terms of the time-based dynamics and alternate initial layouts which could meet these resource requirements. Specific functional element sizes were obtained using current DoD criteria. The overall facility configurations which met the performance objectives best were selected and considerable numbers of micro studies were performed to ensure that each functional element and construction sub-system was as able to respond individually as was the overall configuration. They also ensured that the design did not preclude the introduction of any of the operational improvement alternatives.

An expert consultant, McKee, Berger and Mansueto (MBM) then performed a cost analysis of the design logic output. MBM derived conventional hospital construction costs from their data base which included some 50 military and civilian hospitals. The figure used for comparison represents an average for hospitals built throughout the U.S. since 1968, updated to 1970 and adjusted where unusual site and foundation conditions skewed a specific cost, and indexed from specific locations to a national average. Construction cost savings, present and future, are prospective estimates at best, and may vary drastically for any given location and time frame. The significance of the analysis is that the cost characteristics of the proposed design concept were comparable and not inordinately higher than currently experienced by DoD, and lower than some of the current esoteric concepts for flexibility. The fact that the cost is competitive creates the opportunity for life cycle cost savings by virtue of the design characteristics, which facilitate change and growth, minimize the impact of modifications on operational areas, etc.

MBM estimated the initial construction costs for both this Base "X" facility and a hypothetical facility with the same capabilities designed and constructed in a conventional manner using current criteria. Similar estimates were prepared for each of the changes and growth conditions which match the needs of the Base "X" population. The life cycle costs of both concepts were then compared to determine whether the new design logic could be cost justified.

- Operational Improvements which had been identified and recommended in the generalized parametric analyses were then evaluated and found applicable to the Base "X" environment. The savings to be expected in Base "X" by the introduction of these improvements were then calculated by computing the differences in the following items between the Base "X" current criteria requirements and the improved version: estimated life cycle costs, first year operating costs, personnel, and space.

The last step involved the application to these Base "X" data of a proprietary computer-based evaluation tool which Westinghouse has developed, based on dynamic programming. All life cycle costs for Base "X" optimal strategies, "current" criteria and "improved" criteria, were calculated and the life cycle cost savings for the "improved" version compared to the calculation generated in the operational analyses. Both methods of calculation are in close approximation. Further runs of the program illustrated the effects of various procedural, budget, and policy constraints on the life cycle costs, i.e. BOB limitations on the availability of funds for capital expenditures for specific requirements, DoD policy changes relative to fractions of beneficiary population served, and hospital utilization policy modification effecting shorter lengths of stay, ambulatory treatment of certain DoD categories, etc.

PLANNING

As an illustration of the major data inputs used for generating the Demand Model outputs, the following table was extracted from the Base "X" population statistics for example #1:

POPULATION CATEGORY BY PLANNING INTERVAL

TIME	RECR	A DUTY	DEP AD	RETIR	DEP RT
T - 0	0.000	24000.000	34800.000	5900.000	10300.000
T - 5	0.000	24000.000	34800.000	6564.000	11459.000
T - 10	0.000	24000.000	34800.000	7892.000	13777.000
T - 15	10000.000	30120.000	43680.000	9220.000	16095.000
T - 20	10000.000	30120.000	43680.000	10548.000	18413.000
T - 25	10000.000	30120.000	43680.000	11876.000	20731.000

The Demand Model acting on these beneficiary populations at each planning interval produced a statement of the patient care requirements at these intervals.

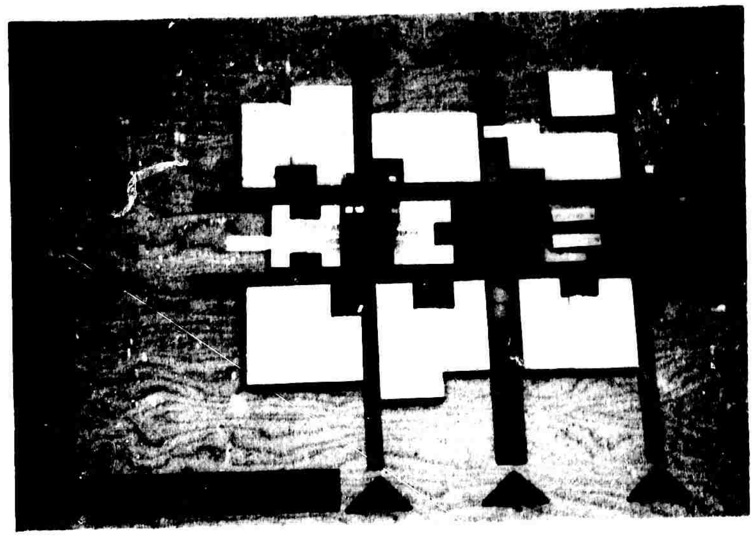
DESIGN LOGIC APPLICATION (CURRENT CRITERIA)

Ambulatory Level (Figure 25)

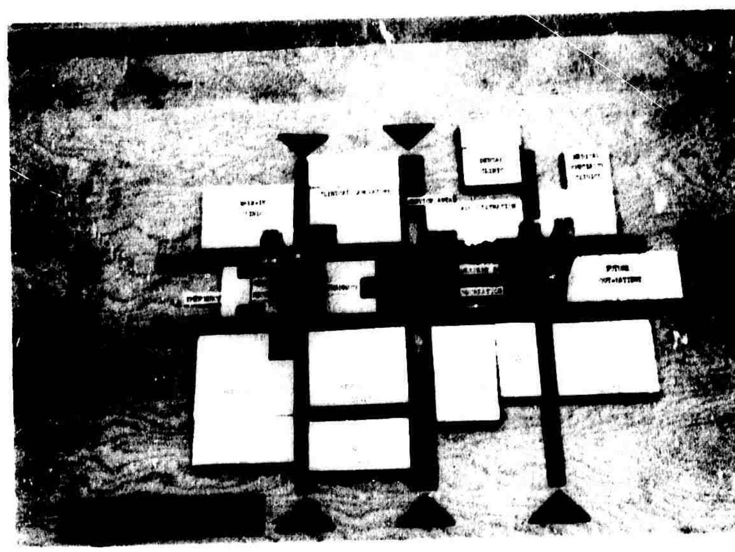
The elements of the ambulatory level are organized on a variable patient-entry concept. The primary adjacencies were established by computer

FIGURE 25. AMBULATORY LEVEL

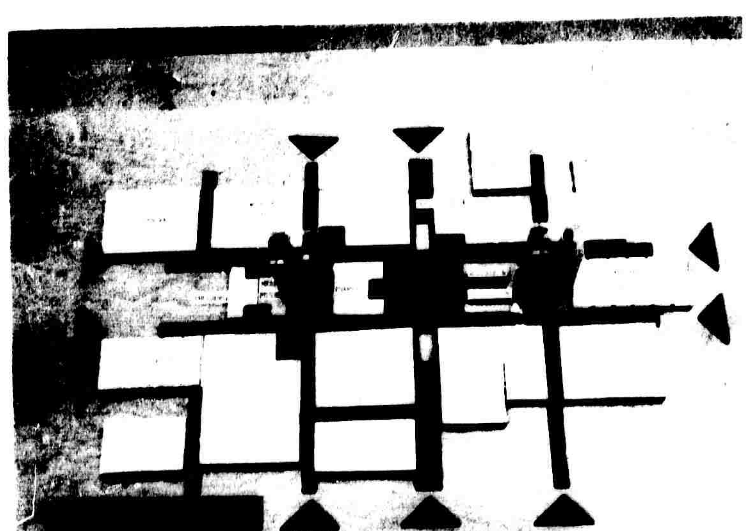
T_0



T_{10}



T_N



optimization of the interrelationship of staff, communications, and patient flows. This resulted in a 26 % reduction in the total flow requirements. These elements can accept the varying operational requirements and the large column-free areas permit minor changes and modifications. The T_{10} (time-ten years) capability of ambulatory level elements allow the open-ended expansion of some clinics within the parameters of the time-distance relationship to the major nodes and the limits of efficient internal layout. Other clinics can grow by displacement into adjacent areas and by construction of new clinic elements within an extended ambulatory level.

The ultimate (T_N) capability of the ambulatory level indicates how a very large BLHC System may incorporate satellite health care elements such as a dispensary or an outpatient surgery function.

Medical and Professional Level

The elements of the medical and allied professional level are related to the ambulatory level by vertical adjacencies through the primary and secondary circulation nodes. Flexibility of this level to change is enhanced by accessibility of mechanical services in the large clear span modules (3 - 75' x 450'). The step function growth of major health care elements (surgery and delivery) is accommodated by expanding into unfinished space provided for this purpose. Modules of growth for surgery may occur in increments of 2 or 4 theaters from an initial demand range of 6-8 theaters at T_0 to a total of 12 surgical theaters at T_N.

Service Level Structural Transfer Zone

The service level, directly integrated into the structural transfer zone, is placed nearest to the elements dependent on service support, namely, the inpatient levels and other discrete sub-system vertical adjacencies (e.g., central sterile to surgery and delivery).

Vertical Nodes

The vertical nodes have been described as the umbilical cord which provides the vertical movement of people and the distribution of services within the BLHC System. Their specific application to Base "X" has required more detailed analysis of the functions of the nodes. The primary nodes contain specific numbers of elevators tied directly to the modules of inpatient activity as a function of time. The ultimate growth limits of the total system are determined by vertical lift capability. Each primary node also contains stairs for local vertical circulation. Also assigned to the primary nodes are materiel distribution and secondary mechanical distribution.

The secondary nodes, which also have stairs for local vertical movement, contain the major mechanical, electrical, and utilities distribution from the service level. One secondary node contains a freight elevator for service deliveries to the warehousing area on the service level.

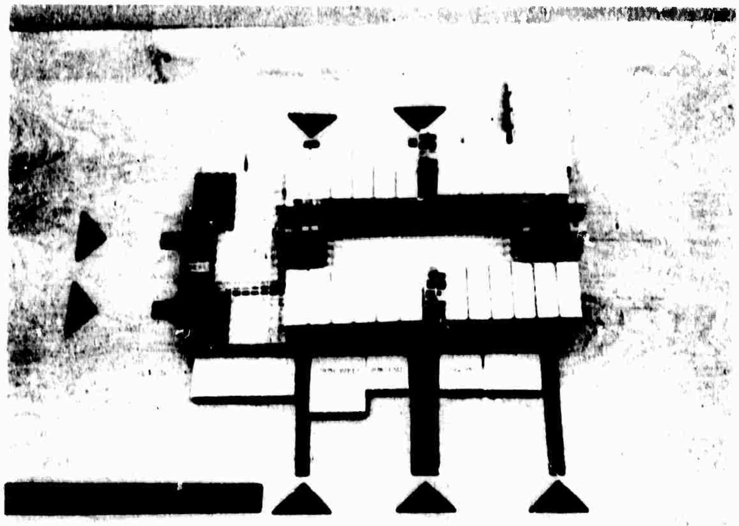
Inpatient Configurations (Figure 26)

The inpatient demand for Base "X" can be met by many configuration alternatives. These are based on two or three level inpatient configurations combined with on-grade, three-level light care units. Patient care units are assigned a nominal density of 34 beds with the understanding that it can be varied by levels of dependency, ranging from a low of 16 to a high of 48 patients per ward as concepts of progressive or modified progressive patient care are applied.

The patient capsule can accept various combinations of single, double, three, or four man rooms (Figure 27). Fixed services such as plumbing are provided on the periphery to free as much space as possible in the central area of the nursing units. For operational flexibility, light care areas were designed as a component of the inpatient configuration to accept swing demands from higher levels of care.

T_0

570 Beds
4 NU at 3 Levels
& Light Care



T_0

570 Beds
6 NU at 2 Levels
& Light Care

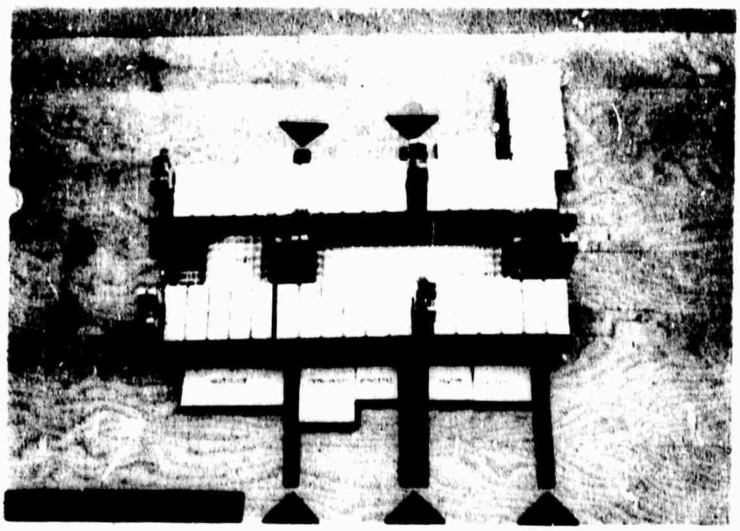


FIGURE 26. INPATIENT CONFIGURATIONS

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MICRO STUDY
PATIENT CAPSULE

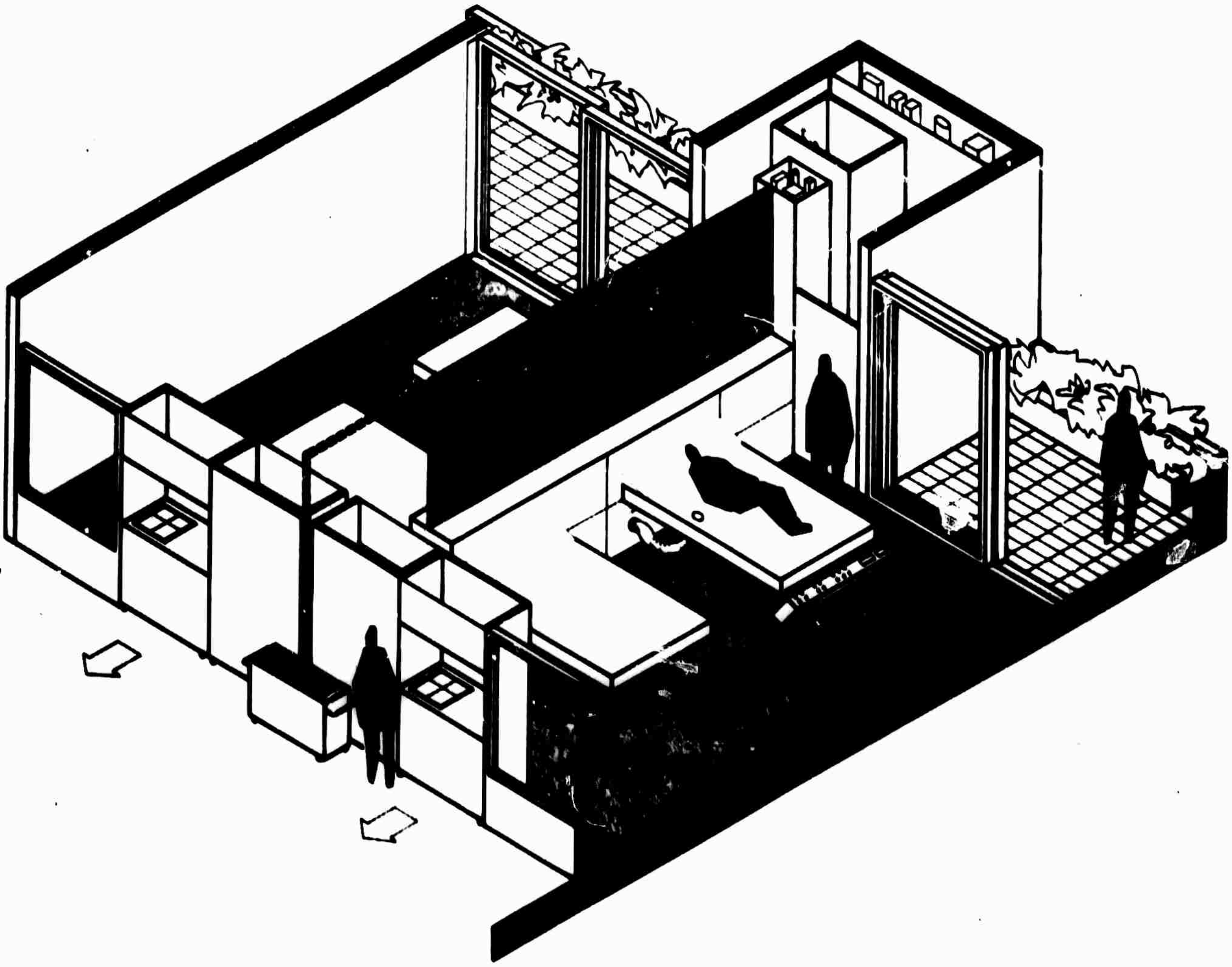


FIGURE 27. PATIENT CAPSULE

The ultimate bed capability (T_N) of the system is determined by the initial decision between two-versus-three inpatient levels (Figures 28 and 29). The ultimate capability of the two-level system is approximately 820 beds, and the three-level system approximately 1100 beds.

Micro studies on many design aspects were performed to illustrate specific operation improvements, as well as Health Care Review Team recommendations. In addition, major construction and support systems were studied to define the most appropriate technology alternatives. Examples of these studies are in Figure 30, the proposed structural system, and Figure 31, the materiels distribution pattern.

Life Cycle Cost Comparison

Consultants analyzed the Base "X" configuration for T_0 and a facility with comparable health care capabilities designed and built in the conventional manner. Their construction estimates are:

T_0 - NGMH (Current Criteria) 507,150 sq. ft. at $49.00 per sq. ft.

T_0 - Conventional Facility 453,800 sq. ft. at $47.00 per sq. ft.

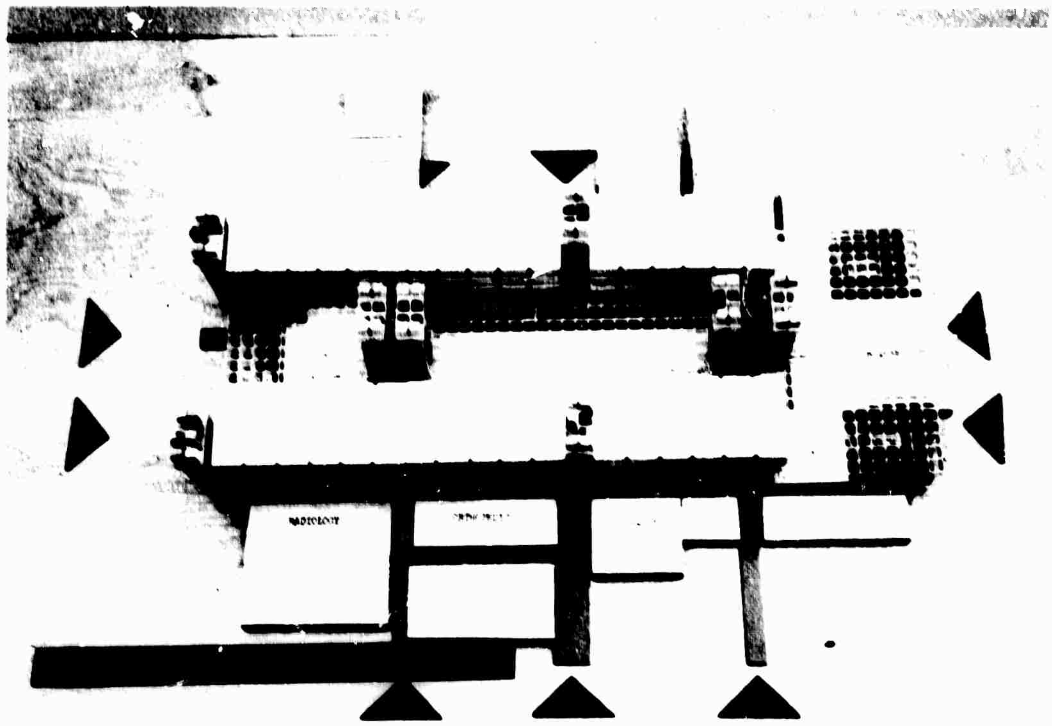
The new design logic shows a $2.00 per sq. ft. higher construction cost compared to the conventional approach: it also provides an additional 10 percent total space. The next step in the life cycle cost comparison was to compute the space changes, modification costs, and degree of disruption to the existing facility as the facilities respond to the Base "X" health care needs over time.

At T_{10} the new design logic would allow all the capability to be added in 187,050 square feet of new space at a cost of $51.47 per square foot compared to the need to add a total of 240,000 square feet of new space in the conventionally designed facility at a cost of $65.92 per square foot. In addition, the alterations required to the T_0 configuration are only 25,357 square feet at $58.51 per square foot in the new design, compared to 68,070 square feet at $73.38 in the conventional design. These figures indicate that only one

FIGURE 28. INPATIENT CONFIGURATIONS

$T_{10\text{-}15}$

890 Beds
Example 1



T_{10}/T_N

820 Beds
Example 2

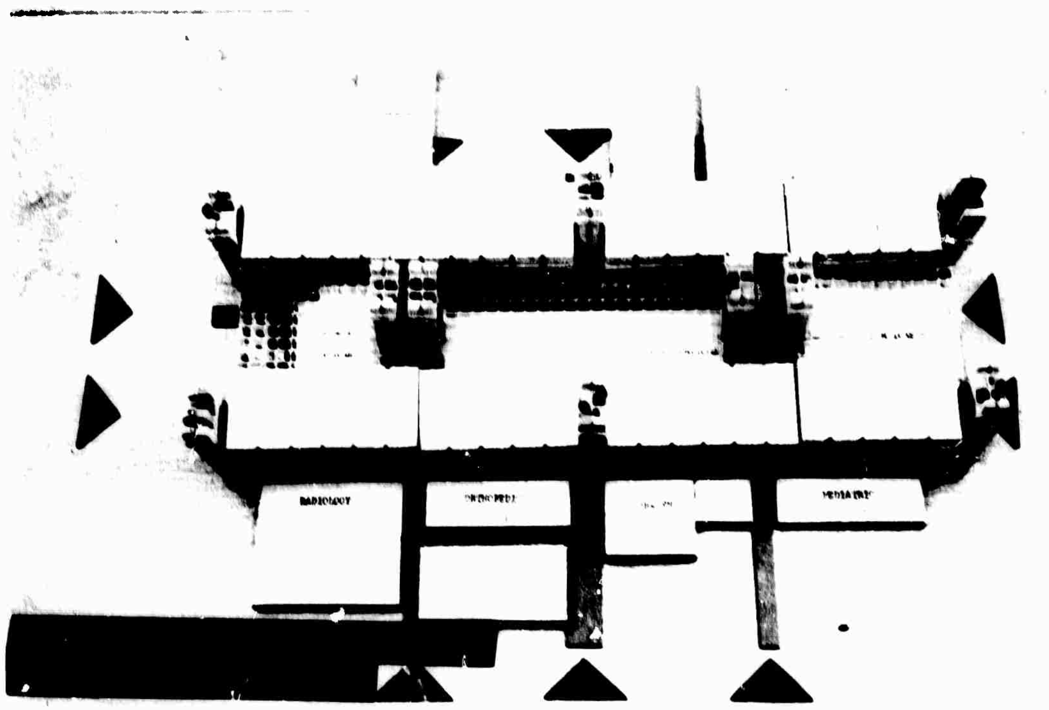


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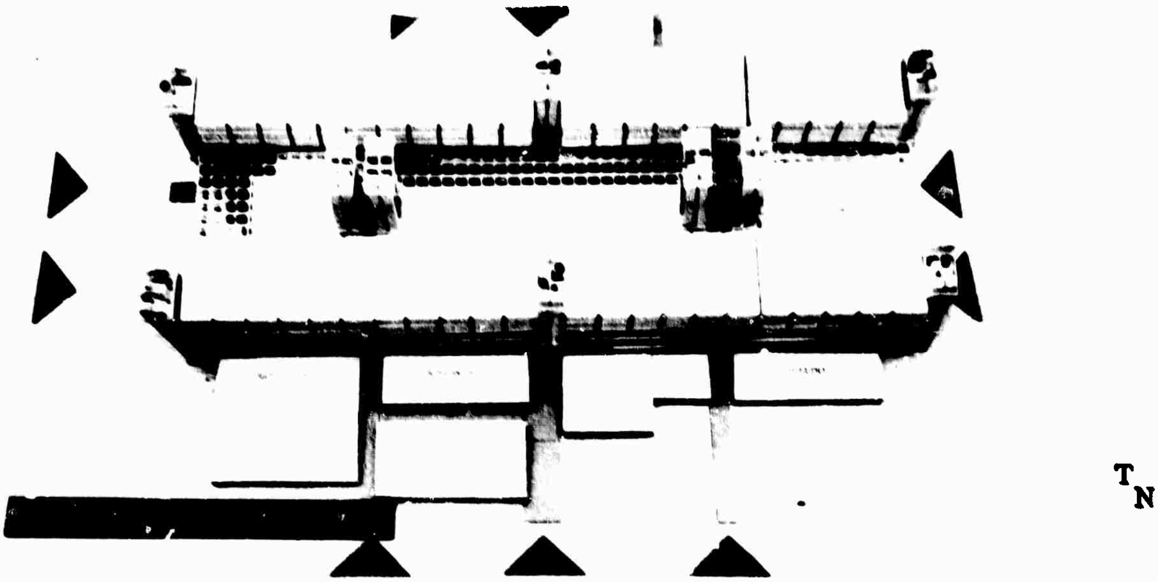
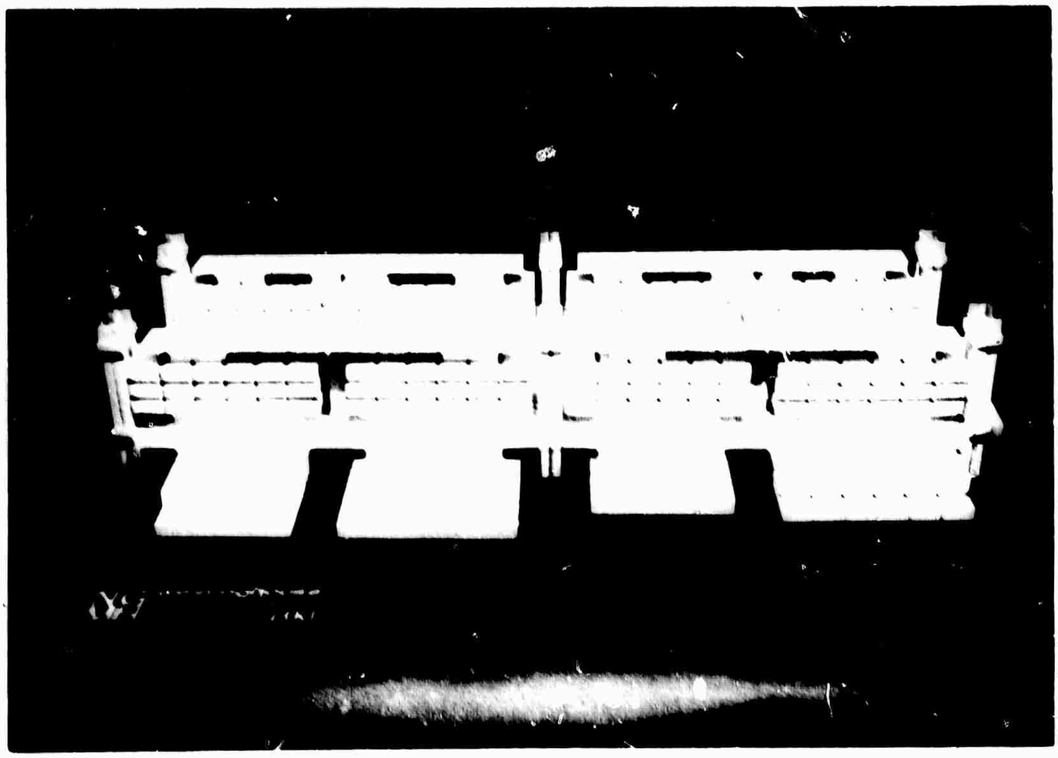
FIGURE 29. TOTAL CONFIGURATION POTENTIAL



GENERAL DESIGN MODEL



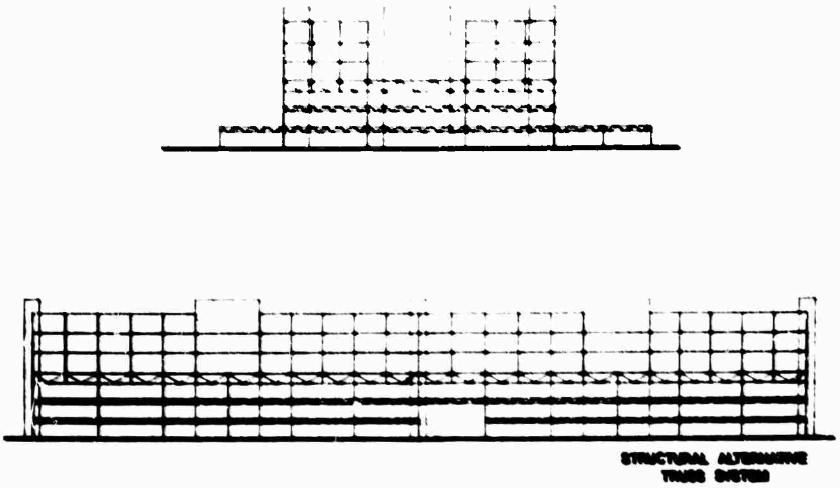


FIGURE 30. TWO-WAY TRUSS STRUCTURAL ALTERNATIVE

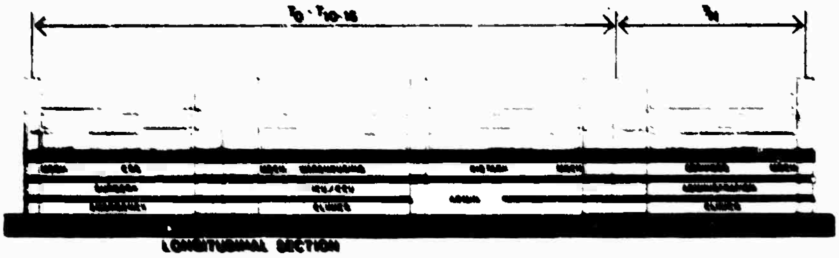


FIGURE 31. MATERIEL DISTRIBUTION PATTERN

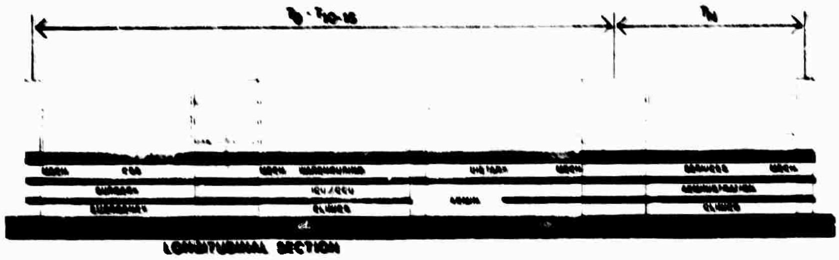


FIGURE 32. DIETARY DISTRIBUTION PATTERN

major change in the demand is required for the new design logic to be cost justified. Any further changes will increase the savings realizable by the improved design. This cost justification does not include any credit for the lowered operating costs and the ease with which less significant changes can be accomplished. Figure 33 shows the comparison of construction costs.

OPERATIONAL IMPROVEMENTS

The analyses of potential operational improvements in ten major areas had resulted in generalized conclusions and recommendations for their use in BLHC Systems. Base "X" was assigned a set of specific characteristics and requirements. Each of the improvement alternatives were reviewed in this context and the estimated life cycle cost savings were calculated for each improvement alternative for Base "X".

In addition to estimated life cycle cost savings, the annual operating costs were calculated to T_0 Base "X" for two modes of operation: the present method and the anticipated effect of the improvement alternatives. The Demand Model established the performance requirements used for both calculations. Present method costs were calculated by applying the functional cost data to these performance requirements. For the analysis process, new method costs were calculated and applied to the same performance requirements. The impact on facilities was also calculated, where possible.

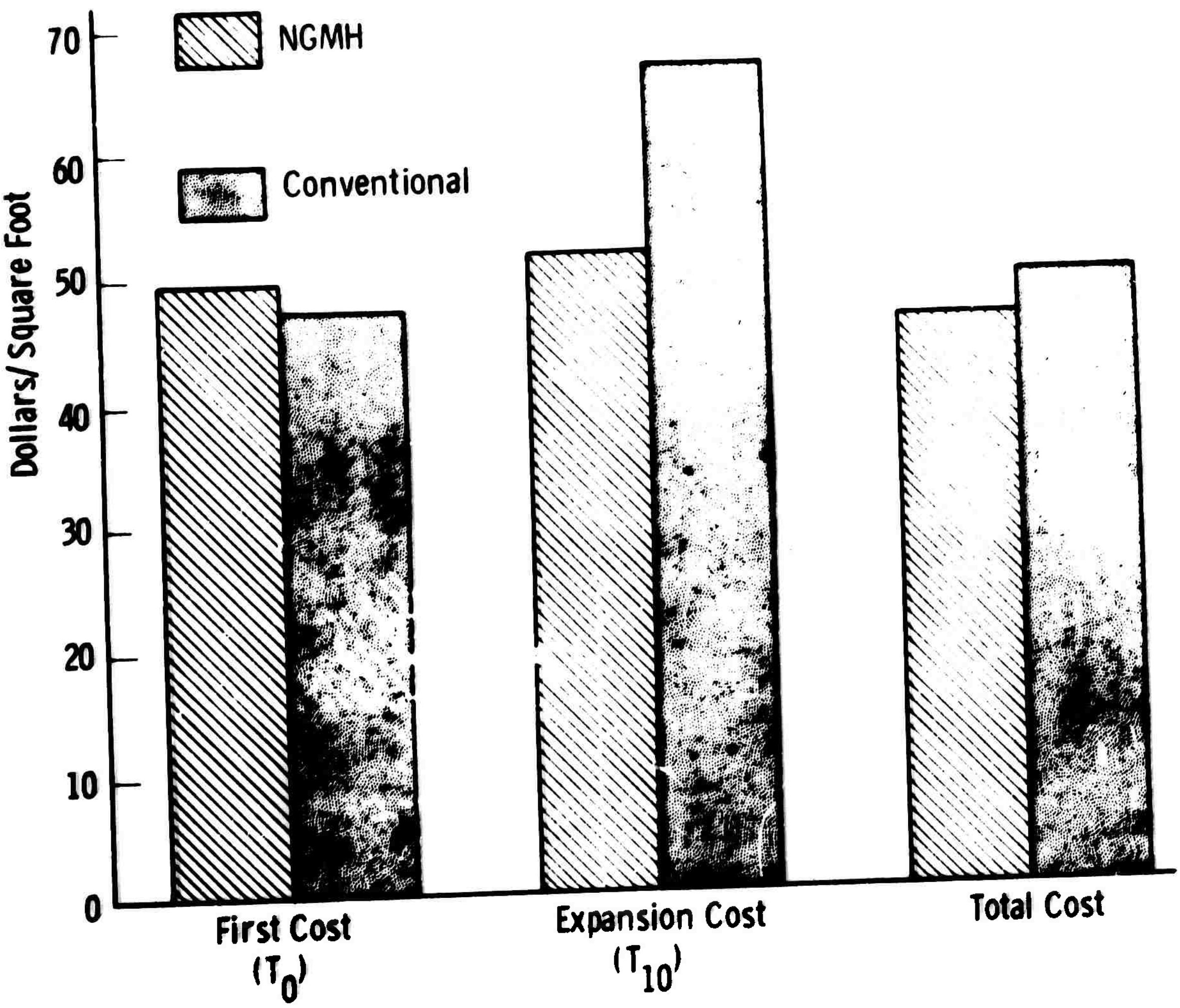


FIGURE 33. COMPARISON OF CONSTRUCTION COSTS - NGMH AND CONVENTIONAL HOSPITAL

These calculations are summarized in the following table:

Operational Alternative	Est. Life Cycle Savings $	Est. 1st Year Operating Cost Savings or Losses $	Est. T-0 Space Reduction sq. ft.
Dietary	8,000,000	455,000	3,500
Materiels Handling	-100,000	-8,000	-----
Comm. & Data Mgmt.	4,650,000	238,000	9,000
Ward Management	2,500,000	252,000	2,000
Dentistry	9,400,000	670,000	2,000
Radiology	1,100,000	73,000	2,000
Pharmacy	950,000	75,000	1,000
Clinical Labs	600,000	34,000	2,500
Education & Training	950,000	64,000	-----
Outpatient Clinics	1,650,000	98,000	10,000
Totals	$29,800,000	$1,967,000	32,000

The T_0 configuration at Base "X" has been calculated at approximately 507,000 sq. ft., at a cost of $24.7 million to construct and at a cost of $11,100,000 to operate using conventional methods of staffing and operations. As shown above, the introduction of these improvement alternatives results in a facility size reduction of 32,000 sq. ft, an estimated construction cost saving of $1,650,000, and an operating cost saving of $1,967,000.

<u>Additional Planning and Design Considerations</u>

The preceding operational improvement alternatives and design configuration improvements included all issues which are fully substantiated in the present analysis. Two additional areas have considerable savings potential but are not fully proven.

- Based on the Health Care Review Team's recommendation of modified progressive patient care, patients may be assigned to nursing units on a sliding scale of density by levels of care, such as, 16 per acute and heavy care ward, 34 per moderate care ward, and 48 per light care ward.
- Replace the current practice of assigning total numbers of beds in a facility by using an occupancy factor of 80 percent of average daily census by a more sophisticated, statistically valid method of aggregating the total number of beds from a probability distribution calculation related to levels of care. Based on the proposed method of assigning operating beds, the 80% occupancy rate represents 99.9% probability that all requirements in all care levels can be served (i.e. the full hospital). The new methodology suggests that by relating the probability to levels of care an overall reduction of beds can be effected. The methodology suggests: 1) an increase in the number of intensive and heavy care beds and 2) a reduction of 10% in moderate care beds, in view of their capability to swing between light and moderate care.

  An approximate 15% reduction in light care beds can be obtained in view of the capability to schedule elective procedures, and options for reducing lengths of stay in light care (convalescent leave, outpatient treatment, etc.). Since most light care patient days are for active duty personnel,considerations of sex mix is not a significant factor.

By comparison to similar civilian facilities, the BLHC System statistics indicate generally longer lengths of stay by recruits and active duty military in light care. If alternative housing arrangements can be provided during the last 25 to 30 percent of their current hospital stay, two basic major economies can be effected:

(1) Smaller facilities can be built with lower operating costs.

(2) The same facility can exhibit a higher throughput in acute and moderate care and absorb the unmet health care demands of the dependent population.

The design concept recommendation states that light care units should be integrated into the overall inpatient system. However, on grade, 2 or 3 story light care units are indicated as part of the ultimate capability of the configuration to provide housing for personnel in administrative holding status. The units are contiguous to the facility so that services (dietary, therapy, ambulatory care, etc.) are available to the patient, and in turn the patient is under effective administrative control of the hospital. Reductions of the magnitude noted in lengths of stay have savings potential of approximately $35 million over the Base "X" life cycle by comparison to current criteria and an additional $7 million using the Base "X" improved criteria.

The Base "X" example illustrated the feasibility of applying the tools and concepts developed by Westinghouse, and their responsiveness to the needs of any BLHC System. The application of these tools will yield measurable dollar savings over the life cycle of the system.

Phase II of this study will be a "prototype" facility; if it approaches the scale of the Base "X" example, these potential economies can be tested.

DYNAMIC PLANNING

Westinghouse was able to employ a proprietary computer-based planning tool based on dynamic programming, which evaluates life cycle strategies for building and expansion. The functional cost data obtained from the BLHC Systems, the Base "X" health resource requirements, configuration characteristics, and operational characteristics were inputs to this planning tool and a considerable number of runs were performed. In addition to evaluating the broad construction strategies, the dynamic planning tool allowed the rapid display of extremely complex and interrelated factors such as changes in assumptions of cost escalations over time for construction, operating costs, and penalties for delays in matching health care capability to health care needs. The life cycle costs for the optimal strategy for the entire BLHC System, as computed using this tool, were extremely close to those computed using the parametric curves.

The parametric analyses used in the operations analyses generally could not simultaneously manipulate changes this large in the basic assumptions. In these last series of program capabilities, dynamic planning acted as broad-based sensitivity analyses which reinforced conclusions generated during the overall study.